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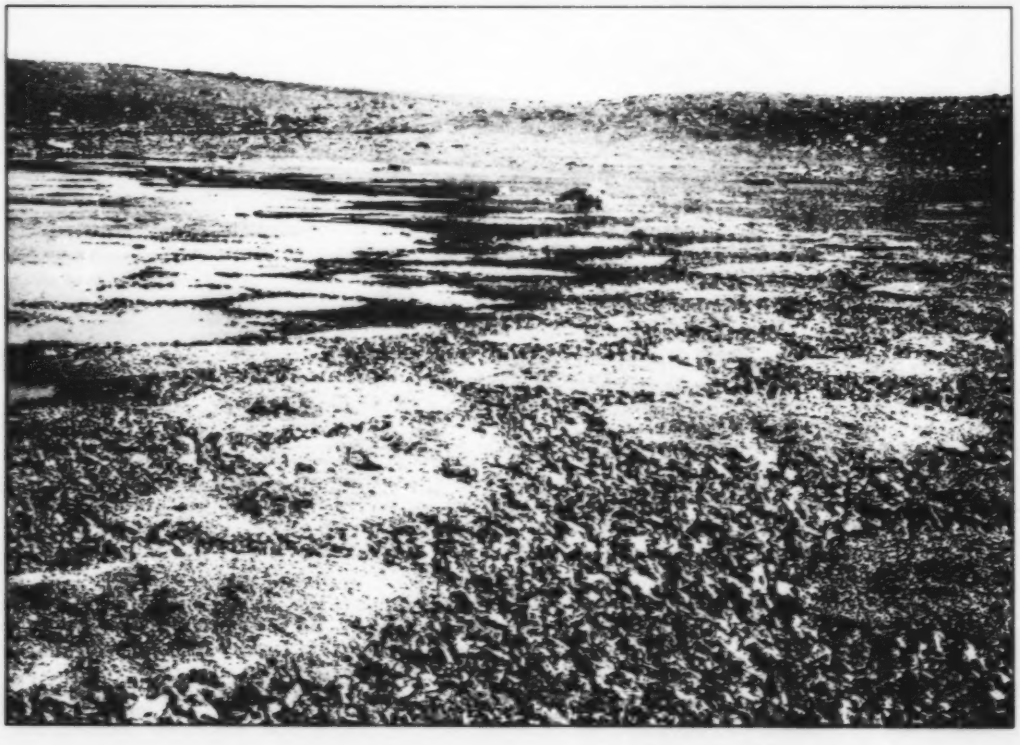
PAPER 89-12

PRELIMINARY SURFICIAL GEOLOGY OF CORNWALLIS AND ADJACENT ISLANDS, NORTHWEST TERRITORIES

S.A. Edlund



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Cover description

Unvegetated polygons consisting of weathered limestone fragments at the borders, and silt with limestone gravel in the centers, central Cornwallis Island.

Critical Reader

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SURFICIAL GEOLOGY OF CORNWALLIS AND ADJACENT ISLANDS, NORTHWEST TERRITORIES

Abstract

The landforms of the Cornwallis Island area are primarily the result of pre-Pleistocene planation and dissection. Faulting during a late Cretaceous-Tertiary rifting episode created the surrounding channels and major valleys on Cornwallis and Griffith islands.

The most widespread surface materials are carbonate rock and its weathered product, residuum. Beach deposits characterize the coasts of the major islands and completely cover small, low lying islands.

There is scattered evidence of Quaternary glaciation, but glacial deposits and features are a minor part of the landscape. Scattered shield erratics and remnants of erratic-rich till indicate that the area was covered by continental ice, probably during pre-Late Wisconsinan times. During the Late Wisconsinan the area was affected by two types of ice masses: 1) the edge of the Laurentide Ice Sheet, which probably extended only onto Lowther Island and 2) a local ice cap(s) over Cornwallis Island. Marine transgression as a result of Late Wisconsinan deglaciation reached to about 120 m a.s.l. in the southern part of the study area and to less than 100 m in the north.

The surficial materials of the Cornwallis Island area are among the least sensitive to disturbance in the High Arctic islands; most areas are traversible. Environmental damage can be minimized by avoiding wet, fine grained materials and vegetated areas. All activities should be curtailed during spring thaw and after heavy summer precipitation. Beach deposits provide an abundant source of gravel, and the carbonate formations are a widespread, potential gravel source. Sand resources are limited.

Résumé

Les formes de relief dans la zone de l'île Cornwallis sont dues principalement à des processus d'aplanissement et de dissection antérieurs au Pléistocène. La formation de failles pendant un épisode de rifting au Crétacé supérieur et Tertiaire a contribué à la crétation des chenaux environnants et des principales vallées des îles Cornwallis et Griffith.

Les matériaux de surface les plus répandus sont des roches carbonatées et leurs produits d'altération. Des sédiments de plage s'étendent sur les rives des îles importantes et recouvrent complètement de petites îles à faible relief.

La glaciation quaternaire a laissé des traces disséminées dans le paysage mais les dépôts et formes glaciaires sont peu nombreux. La présence de blocs erratiques de bouclier dispersés et de bouclier dispersés et de vestiges de till à haute teneur en blocs erratiques indique que cette zone a été recouverte par un glacier continental, probablement avant la fin du Wisconsinien. Pendant le Wisconsinien supérieur, deux types de masse glaciaire ont érodé cette région : 1) la bordure de l'inlandsis laurentidien qui ne devait s'étendre que jusqu'à l'île Lowther et 2) une ou plusieurs calottes glaciaires sur l'île Cornwallis. La transgression marine causée par la déglaciation du Wisconsinien supérieur a atteint 120 m au-dessus du niveau de la mer environ dans la partie sud de la zone à l'étude et moins de 100 m dans la partie nord.

Les matériaux de surface dans la zone de l'île Cornwallis sont parmi les sédiments des îles arctiques les moins susceptibles d'être perturbés; la plupart des zones sont transversables. Pour minimiser les dommages à l'environnement, il faut éviter les matériaux humides à grain fin et les zones recouvertes de végétation. Il faut en outre éviter de réaliser des activités durant le dégel du printemps et après les fortes précipitations d'été. Les sédiments de plage constituent une abondante source de gravier et les formations carbonatées sont une source potentielle et répandue de gravier. Les ressources en sable sont par contre limitées.

INTRODUCTION

Purpose and methods

Petroleum and mineral exploration in the arctic islands has generated a need for terrain information for environmental assessment and land use planning. To meet this need and to extend the mapping of surficial materials in Canada, a survey was initiated in 1975 to gather data in the region of Cornwallis Island (74°25′ to 76°00′N, 92° to 98°W), which lies in the south-central Queen Elizabeth Islands and is the easternmost part of the Parry Islands (Fig. 1).

The project involved interdisciplinary terrain mapping and environmental impact evaluation under the co-ordination of D.M. Barnett, who also studied the nature of the surficial materials, permafrost, and Quaternary history. Auxiliary projects included the study of engineering properties by P. Kurfurst, vegetation-surficial materials relationships and plant communities by the author, and soils by C. Tarnocai (Canada Soils Survey).

Most of the area was mapped by airphoto interpretation, using 1:60 000 scale airphotos. The author relied predominantly on the field notes of D.M. Barnett and L.A. Dredge

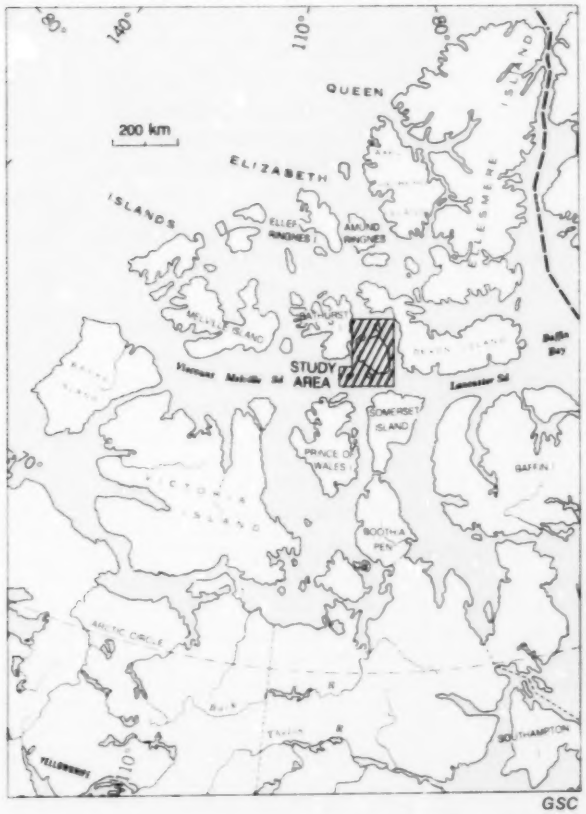

Figure 1. Location map showing study area (shaded) in the Queen Elizabeth Islands, District of Franklin.

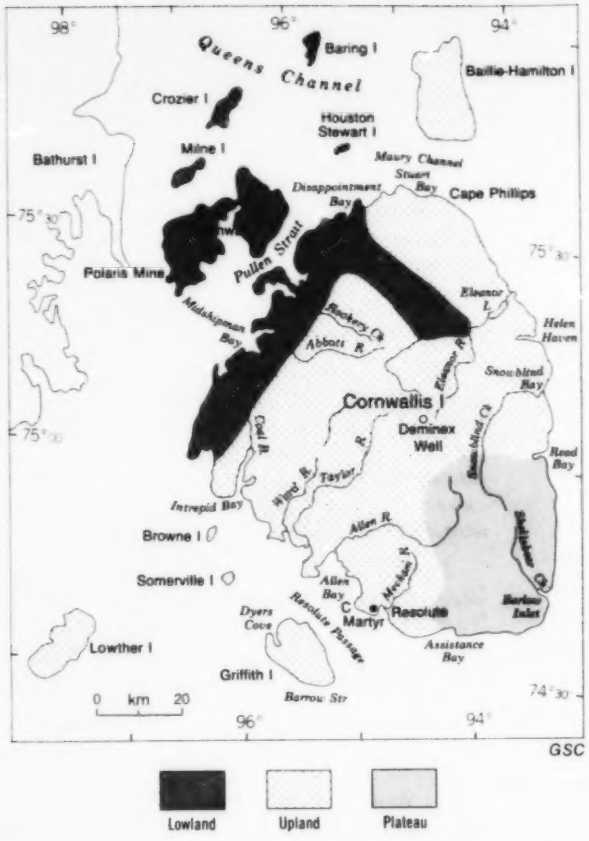

Figure 2. Physiographic units of the Cornwallis Island area.

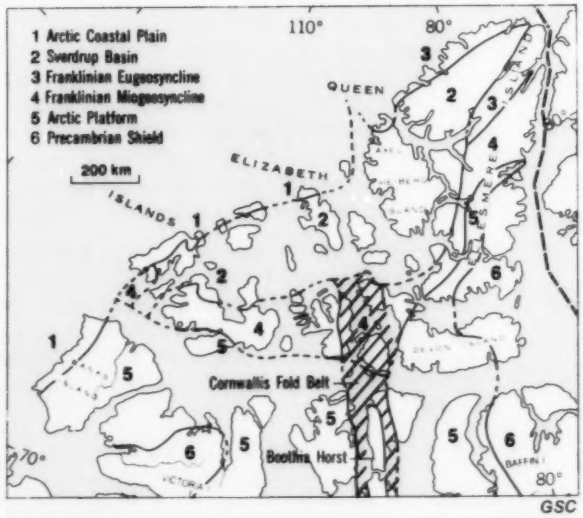

Figure 3a. Cornwallis Fold Belt and adjacent tectonic structures (Kerr, 1977).

and sedimentological laboratory data (Appendix 1) for the description of map units. Preliminary works of Barnett et al. (1976, 1977a) were also helpful.

This report outlines the regional setting of Cornwallis Island and describes the surficial materials; discussion of economic geology and Quaternary history is brief and speculative.

Previous work

Little has been reported on the surficial geology and Quaternary history of the Cornwallis Island area, although in the last 35 years several detailed soils, geology, geomorphic process, and geochronological studies have been undertaken in the vicinity of Resolute Bay, with ready access from the south by air. Preliminary observations of the regional Quaternary history were made by Thorsteinsson (1957, 1958), as part of the earliest bedrock survey. He noted the lack of classic glacial features, yet there was some evidence for glaciation, particularly on the eastern coast of Cornwallis Island. Geomorphic process studies were intitiated by Cook (1955, 1956, 1958, 1960, 1961, 1967; Cook and Raiche, 1962a,b). Mackay (1953), Egginton (1972), and Washburn (1980) have emphasized pattern ground phenomena. Fluvial processes have been studied by Cogley (1975), McCann and Cogley (1973). Scattered collections of whalebone and shells from throughout the map area have assisted in attempts to piece together the Late Pleistocene sea level history (Blake, 1970; Lowdon and Blake, 1978, 1979; Washburn, 1985). Soils in

Table 1. Weathering products of the various parent materials: texture and dominant geomorphic processes

PARENT MATERIAL	TEXTURE	GEOMORPHIC PROCESS
Fluvial deposits	gravels, cobbles, plates, with or without sand and silt; local sand and silt	ice-wedge polygon formation
Colluvial deposits	Silt or silty loam; scree of boulders and gravels with local fines	mass wasting; local slope failure
Marine deposits beach deposits	subangular to subrounded carbonate plates, cobbles gravels with few fines; local sand, silt, or gravel beaches	ice-wedge polygon formation; cryoturbation
nearshore deposits	sand and silt with minor clay and gravel	local thermokarst and mudboil activity
Till and glaciofluvial deposits	silty diamicton with clasts of local or foreign origins	mass wasting
BEDROCK Acidic sandstone (Hecla Bay and Eureka Sound fms)*	sand, fine sand, silt	local ice-wedge polygon formation
Alkaline sandstone (Snowblind Bay and Bird Fd. fms)*	sand, fine sand; gravel, commonly as lag	ice-wedge polygon formation; local wind deflation
Limestone, with siltstone and shale beds (Cape Phillips, Stuart Bay and Irene Bay fms)*	sandy and silty loams with minor gravel; silty diamicton	mass wasting; mudboil activity; cryoturbation
Limestone and dolomite (Eleanor R., Thumb Mtn., Cape Phillips, Allen Bay, Snowblind Bay, Stuart Bay, Disappointment Bay, Read Bay, Blue Fiord, Bird Fiord, and unnamed formations)*	Frost shattered platy or cobbly debris with or without silty fines; some silty loam with minor gravel and silty diamicton	cryoturbation, sorted nets, garlards stripes; local mudboil activity, mass wasting
Gypsum; anhydrite (Baumann Fd, Bay Fiord and unnamed formations)*	silty loam and silty diamicton; local frost shattered debris	mass wasting; cryoturbation

*names used in Thorsteinsson (1958, 1972) and Thorsteinsson and Kerr (1968)

the Resolute area were studied by Cruickshank (1971); preliminary regional observations were made by Tarnocai (1976).

Topography

The topography of Cornwallis Island and adjacent islands is largely determined by the nature of the bedrock and by Tertiary and earlier faulting and dissection. Cornwallis Island is a dome-shaped island with a flat, featureless plateau (200-300 m elevation, with a maximum of 347 m) on the southeastern part of the island (Fig. 2). This plateau is possibly related to the Barrow Surface (Bird, 1967). The island is truncated on the east by coastal cliffs.

The plateau is partially bounded to the north and west by gently rolling hills. In the central part of the island, the hills are subdued, with long, low angle slopes. Towards the margins of the island there is somewhat greater relief, as a result of deeper valley incision. In a few places, the upland is interrupted by broad graben.

Lowlands have developed on less resistant strata (argillaceous limestone, siltstone, shale, sandstone) along the western and northwestern coast and inland along the 'Disappointment' and Eleanor rivers (Fig. 2). Lowlands cover about 15% of Cornwallis Island. Some grabens, such as the Dyer Cove, Intrepid Bay, and Taylor River grabens (Fig. 3), form local lowlands.

The adjacent islands have a variety of topographic forms: Baillie-Hamilton (maximum elevation 242 m) and Browne (157 m) islands are gently rolling uplands bounded by cliffs; Griffith (201 m) and Lowther (199 m) islands are dome-shaped uplands, with local lowlands in grabens; Little Cornwallis (136 m), Somerville (82 m), Baring (109 m), Milne (113 m), Crozier (96 m), and Houston Stewart (85 m) islands are low lying, probably representing an extension of the Cornwallis lowland system.

Bedrock

The bedrock in the study area ranges in age from Ordovician to early Tertiary (Table 1). Resistant carbonates underlie much of the study area (Fig. 3). Most formations consist of limestone and dolomite, which were formerly continental shelf deposits. Gypsum and anhydrite formations occur in the north-central part of Cornwallis and on Lowther and Little Cornwallis islands. A few bedrock formations and facies consist of sandstone, argillaceous limestone, siltstone, and shale, reflecting intertidal, supratidal, deltaic and alluvial deposits (Thorsteinsson, 1957, 1958, 1972; Thorsteinsson and Kerr, 1968).

Sedimentation was continuous from the Ordovician through the Early Devonian but was interrupted from the Early Devonian to the Late Cretaceous. In Late Cretaceous or early Tertiary time, fluvial quartz sands and silts were deposited but are preserved in only a few places.

The older marine sediments were deposited in the region of the crystalline basement of the Boothia Horst (Fig. 3A; Kerr and Christie, 1965). Between the Early Silurian and Late Devonian, four main pulses of tectonic activity in the Boothia Horst caused folding, faulting, and erosion of the marine sediments, creating the Cornwallis Fold Belt. After each pulse, carbonate sediments were deposited and subsequently incorporated into the Cornwallis Fold Belt (Kerr, 1977). During the Late Devonian, however, the Ellesmereian Orogeny in the northern Arctic Islands caused faults to be reactivated, creating numerous major grabens such as the Eleanor, Ward, Allen, Sheringham, Claxton, and Becher grabens (Fig. 3B).

From Cretaceous through Tertiary time, the Eurekan Rifting Episode (centred to the northeast of Cornwallis Island) caused the Cornwallis Fold Belt to be fragmented by faults (Bornhold et al., 1976), and downfaulting resulted in the Intrepid Bay, Taylor River, and Dyer Cove grabens (Fig. 3B). Tertiary faulting was likely responsible for major downfaulting, which created the adjacent channels (Fig. 2), namely Barrow Strait between Cornwallis Island and Somerset Island (Kerr and de Vries, 1977), Crozier Strait between Little

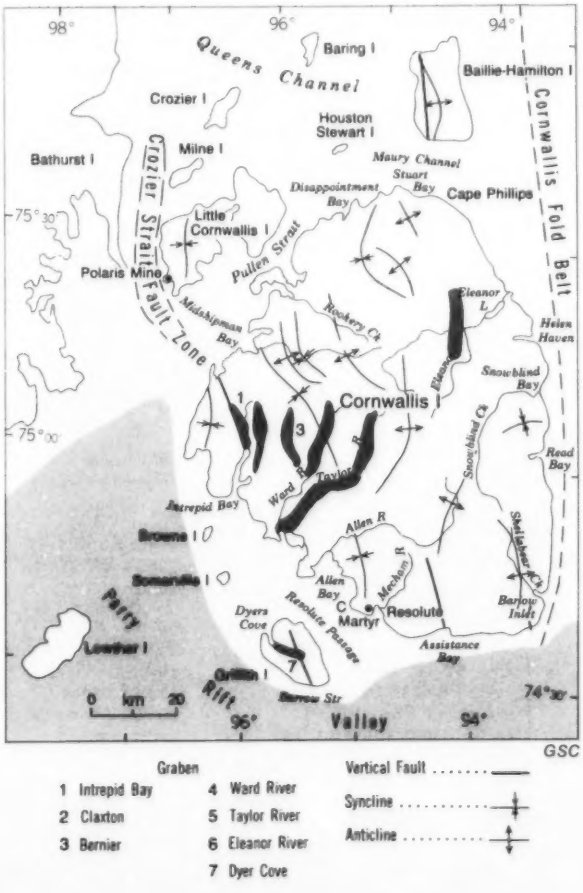

Figure 3b. Major fault zones and graben (after Kerr, 1977; Kerr and deVries, 1977; Kerr and Ruffman, 1979).

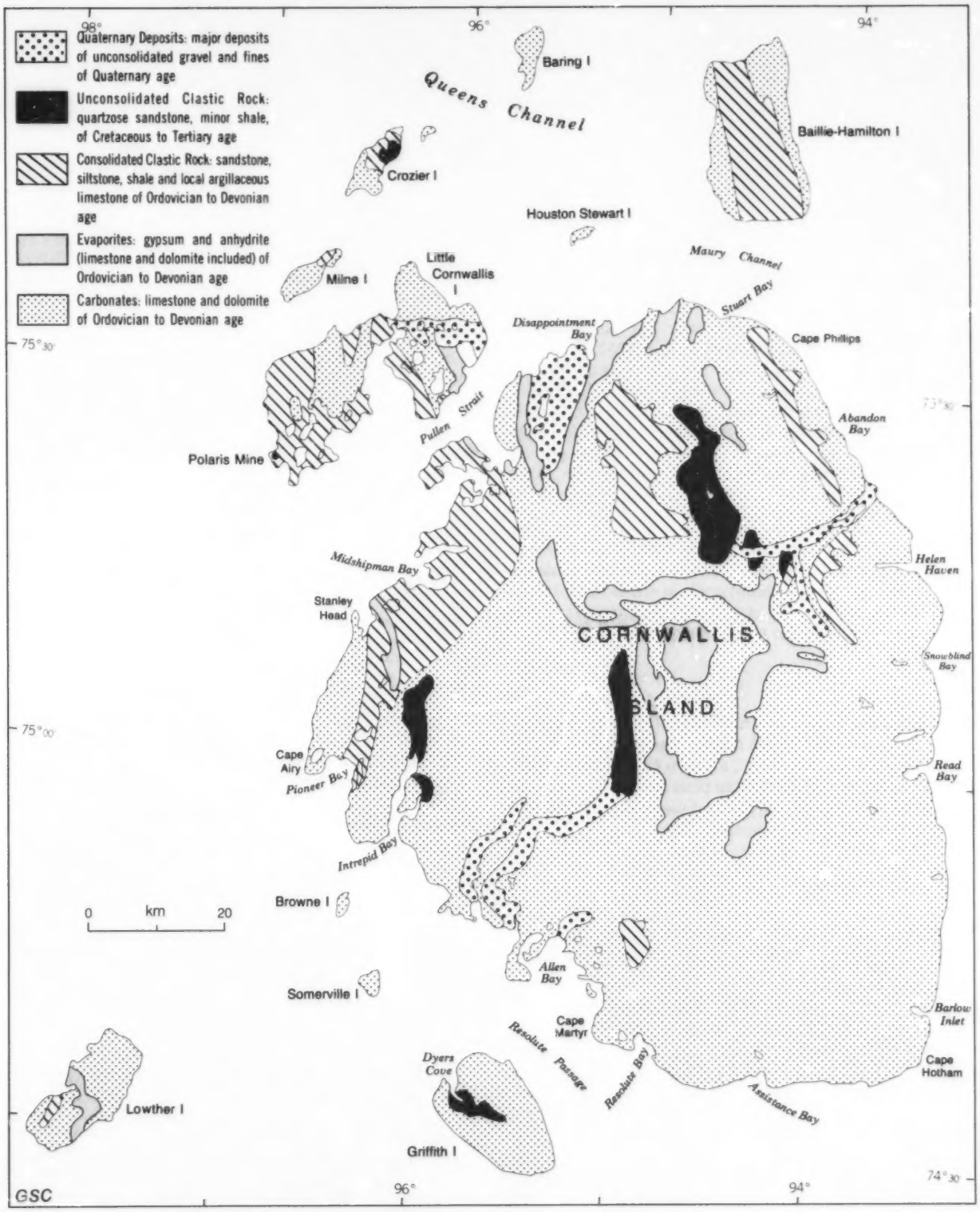

Figure 3c. Generalized bedrock groups (after Thorsteinsson, 1972; Barnett et al., 1977).

Cornwallis Island and Bathurst Island (Kerr and Ruffman, 1979), and Queens Channel between Baring and Crozier islands and Bathurst Island (Kerr and Ruffman, 1979). This faulting may also be responsible for Wellington Channel.

Glaciation had only local effects on the physiography of the island.

Climate

The Cornwallis Island area has a climate typical of High Arctic regions (Table 2), for it has long, cold, dark winters with little precipitation, and short, cool summers with continuous daylight. The surface materials are frozen from September through to early to mid June. Summer temperatures rarely exceed 10°C with a mean daily July temperature of 4.1°C (Atmospheric Environment Service, 1982). Rainfall is light, totalling about 45 mm and falls mainly as light showers and drizzle. Maximum snowfall occurs in September and October when negative temperatures are still moderate. Total snowfall is low (83.8 cm), and the snow is unevenly distributed over the landscape by persistent winds, usually from the northwest or northeast, which remove snow from hillcrests and upper slopes and deposit substantial snowdrifts in valleys and sheltered locations.

Although total precipitation is low, classifying the area as a desert, the summer air is moist because of the high incidence of fog generated in the adjacent straits in mid to late summer. Moisture is usually present in the active layer, especially near the frost table, even if the surface is dry.

Soils

The study area lies well within the zone of continuous permafrost. The active layer, which reaches maximum depth in mid to late July, varies from 10 cm thick on fine grained, poorly drained materials with continuous moss cover, to about 70 cm on coarse, well drained, unvegetated materials. The average depth is less than 50 cm (Appendix 1).

Soil development is minimal in this harsh climate. Cruickshank (1971) showed that Polar Desert soils are dominant in the Resolute area. There is usually little profile development or recent incorporation of organics into most materials. Tarnocai (1976) attributed the lack of soil development to extensive cryoturbation and to the extremely high carbonate content of most soils.

Geomorphic processes

Common geomorphic processes in the area are frost cracking, and subsequent ice-wedge development, frost heaving, cryoturbation, and development of various kinds of patterned ground including mudboils, solifluction, rill and slope wash, and stream erosion (Cook, 1956, 1958, 1960, 1961; Egginton, 1972; Washburn, 1980; Dyke, 1981). As much of the study area is unvegetated (for example, 80% of Cornwallis Island), fine materials at the surface are more readily mobilized by rain and sheetwash. Slope and rill wash, most active during spring thaw, transports a substantial amount of fines downslope (Wilkinson and Bunting, 1975). Rivers in the area have peak flow around the first two weeks in July (Cogley, 1975; Cogley and McCann, 1975; Walker and Lake, 1975); this coincides with peak erosion by streams. Once snow has melted, stream flow is reduced, and by mid August most streams stop flowing or show minimal flow due to an early freeze up at higher elevations.

Widespread mudboil activity is most likely to occur during summer when the active layer is saturated, particularly on materials with a high proportion of fines. Solifluction also occurs at this time, and both may be activated after heavy rain or melting of summer snowfall.

Frost heaving of rock fragments is probably most active during autumn freezing and winter. As the ground freezes soil is displaced and stones are heaved towards the surface. This cryoturbation results in extensive patterning of the surface as sorted nets, garlands, and stripes, particularly on upland surfaces.

Table 2. Temperature and precipitation data for Resolute, Northwest Territories, 1951-1980

RESOLUTE A 74°43'N, 94°59'W elev. 67 m	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ANN
Temperature (°C)													
Daily maximum	-28.4	-29.6	-27.8	-19.2	-7.7	1.7	6.8	4.7	-2.9	-12.0	-20.9	-25.7	-13.4
Daily minimum	-35.7	-36.8	-35.0	-27.0	-14.1	-2.9	1.4	-0.1	-7.2	-18.3	-28.0	-32.9	-19.7
Daily mean	-32.1	-33.2	-31.4	-23.1	-10.9	-0.6	4.1	2.4	-5.1	-15.1	-24.5	-29.3	-16.6
Precipitation													
Rainfall (mm)	0.0	0.0	0.0	0.0	T	5.3	19.1	24.6	3.7	T	0.0	0.0	52.7
Snowfall (cm)	3.4	3.1	3.1	6.5	9.2	7.0	3.3	6.7	15.3	14.8	6.1	5.3	83.8
Total precip. (mm)	3.3	3.0	3.0	5.9	8.1	12.1	22.5	31.1	18.0	13.8	5.7	4.9	131.4

T = trace
Source: Atmospheric Environment Service, 1982

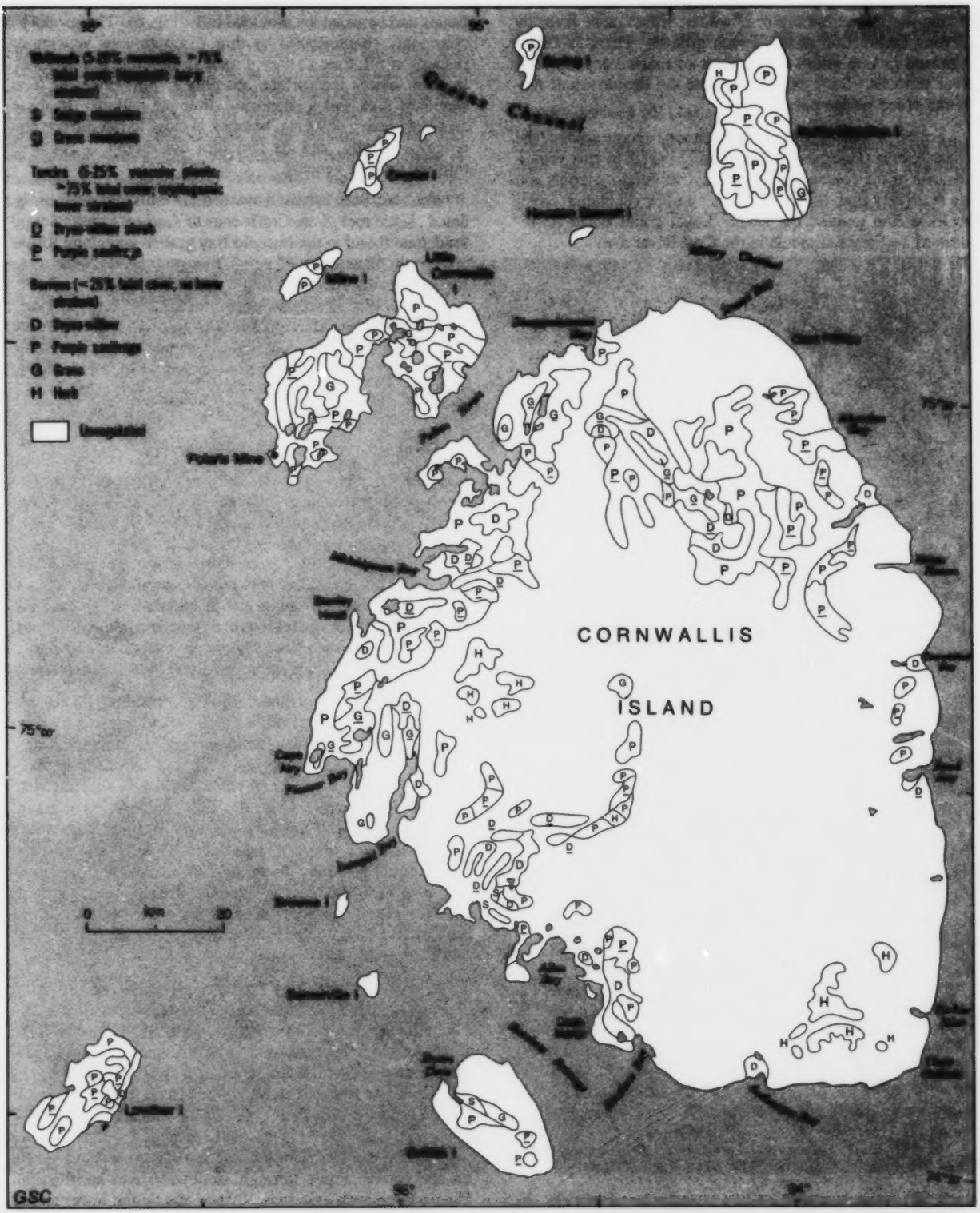

Figure 4. Vegetation of the Cornwallis Island area.

During the extremely cold winter, frost cracks form by thermal contraction of the frozen ground. These are most common in fine grained sediments of marine deposits and river terraces. Such cracks promote the development networks of ice wedge polygons.

Eolian processes, which are common in some areas of the High Arctic (Hodgson, 1982), are limited in this region because of the coarse texture of most surficial materials and the relatively high moisture content and/or vegetation cover on local fine grained materials. Local dunes occur on reworked Tertiary sediments in the Coal River area.

Vegetation

The vegetation is controlled both by climate and by the composition of soil; in the common absence of soil profile development, vascular plants must root directly in the mineral soils. Approximately 80% of Cornwallis Island is unvegetated and another 15% has less than 20% cover (Fig. 4; Edlund, in press). This is primarily due to strong alkalinity of the carbonates, which provide minimal nutrients and are perhaps toxic to plants (Edlund, in press).

The climate is so harsh that most vascular plants in the area are herbaceous (nonwoody), with dwarf shrubs restricted to coastal and lowland sites. Plant diversity in the area is low; only 72 vascular plants have been found (Edlund, in press).

Vegetation is best developed on weakly alkaline materials, such as argillaceous varieties of limestone, sandstone, and siltstones, as well as some fluvial and marine deposits which are a mixture of materials and thus have a greater variety of nutrients. The plant communities on those materials, however, still reflect the calcareous nature of the soil for calciphilous species are dominant or abundant in most plant communities.

SURFICIAL MATERIALS

Figure 5 shows the six main groups of surficial materials of the study area: rock, residuum, till, and marine, fluvial, and colluvial deposits. The reader is referred to Figure 5 for the distribution of surface materials.

Rock and residuum

Together bedrock and residuum cover about 75% of the surface of Cornwallis, Griffith, Lowther, and Baillie-Hamilton islands. These units are local or absent on the low lying islands of McDougall Sound. Rock and residuum are distinguished on the basis of morphology and depth of weathering, and are further subdivided on the basis of the lithology.

Rock (R)

Rock (R) comprises surface and near surface bedrock. In some places the terrain is irregular, having hilly to low, hummocky topography (*R), with ridges that may or may not be directly related to bedrock structure. Drainage is deranged and numerous lakes and ponds occur in ice scoured rock basins and between ice moulded hills (Fig. 6). The surface is commonly characterized by thin, discontinuous veneers or pockets of till, frost shattered rock, or raised beach deposits. In other places the surface has only a thin veneer of frost shattered rock and a dendritic drainage pattern. In these areas of veneer, however, bedrock is close to the surface and outcrops locally, and its structure commonly is apparent through the thin veneers.

Rock has been subdivided into three units: R1, unconsolidated clastic rock, Late Cretaceous to Tertiary Eureka Sound sandstone found in the Intrepid Bay graben and along Rookery Creek, Cornwallis Island; R2, consolidated clastic rock, sandstone, siltstone, shale found on northwest and south-central Cornwallis Island and parts of Little Cornwallis and Baillie-Hamilton islands; and R3, consolidated carbonate rock (limestone, dolomite) and evaporite rock (gypsum and anhydrite), which is the most widespread rock unit in the study area.

Residuum (1)

In contrast to the rock units, residuum (1) is characterized by gently rolling terrain or plateaus with long, uninterrupted slopes, integrated drainage, and no lakes or ponds. Solid bedrock is almost completely masked by platy fragments or stony diamicton derived from the weathering of underlying bedrock. Outcrops occur only locally as tors, as cuestas, and in nivation hollows. In many places patterns of bedrock structure and colour variations are preserved in the residuum, even though it has been weakly sorted into nets and polygons on level terrain and into stripes and garlands on slopes.

Residuum has been subdivided into residual veneer and residual blanket, based on the texture and thickness of the weathered material. Weathered veneer (1a), is mantled by a thin layer (generally m) of frost-shattered debris. It is subdivided on the basis of lithology: unit 1a1 is composed of weathered clastic rock consisting of alkaline debris of gravel sand and silt and occurs in a band on northern Cornwallis Island and locally in one area south of Allen River; these materials are generally moderately vegetated. Unit 1a2 consists of a veneer of frost-shattered carbonate and evaporite rock composed of platy fragments or more equi-dimensional gravels with minor amounts of highly alkaline fines. This unit is generally unvegetated.

In central Cornwallis Island, carbonate and evaporite bedrock is masked by a blanket of sandy silt or loamy diamicton with varying amounts of gravel (unit 1b). It appears to be derived from deep, more complete weathering of the underlying bedrock than occurs on unit 1a2. Although the thickness of unit 1b was not determined, it extends below the active layer for at least 1 m. The texture of the diamicton varies with topographic position; hilltops and upper slopes contain more gravels whereas the more mobile finer fraction accumulates on the lower slopes through slopewash and solifluction. Where large accumulations of fines mantle the lower slopes and valley bottoms, they are mapped as colluvium (5a). In some areas unit 1b may be derived in part from a local till which has since been subjected to intense cryoturbation and solifluction.

Till

Patches of thin (less than 1 m to locally several metres thick), discontinuous veneers of till occur on the plateau and uplands of Cornwallis Island, and on Lowther, Baillie-Hamilton, and Little Cornwallis islands. Till covers less than 5% of Cornwallis Island and 30% to 50% of the smaller Lowther and Baillie-Hamilton islands. No bedrock structure is visible in these deposits which generally conform to the bedrock topography. They are divided into two types: those derived from local carbonates and those with abundant shield erratics. Striations on clasts in some sediments aided in the identification as till.

Locally derived till (2a)

Locally derived till is composed of a grey-brown stony silty loam which is highly alkaline. These deposits are textually indistinguishable from residuum (unit 2) and are distinguished only by their topographic position mainly on

Figure 6. Ice scoured bedrock (R2), and moraine-like feature at the base of Marshall Peninsula, northwestern Cornwallis Island. NAPL A16194-135.

interfluves and by their lack of structural lineations. Some of the gravels are striated. Where till is locally several metres thick, the surface of unit 2a commonly has high centre polygons, 10-15 m in diameter. In some areas, such as the upland south of Eleanor Lake, minor thermokarst ponds occur.

Till with abundant shield erratics (2b)

Till with abundant shield erratics occurs on Lowther Island and on the southern plateau of Cornwallis Island. On Cornwallis Island this till is easily distinguished from units 2b and 1 by its dark grey tone on airphotos (Fig. 7).

The till consists of a sandy to sandy silt loam with gravels of both local carbonates and abundant erratics of southern provenance, particularly pink granite and other igneous pebbles. Some clasts at the surface show pitted structures indicating long term chemical weathering. Shell fragments also occur in the fines. Sand-silt-clay ratios average 45-33-22 (6 samples, Appendix 1). This till is moderately alkaline (pH 7.4-7.8) compared to that of unit 2a.

On Cornwallis Island, unit 2b is highly solifluctcd. The surface of till is flat and featureless. No underlying bedrock structure is visible, nor are there typical glacial landforms. The materials are poorly drained; saturation below a few centimetres depth is common. On Lowther Island, the clasts at the till surface have a smoother, less pitted appearance (this is called a 'fresh' appearance by Barnett et al. (1976a)).

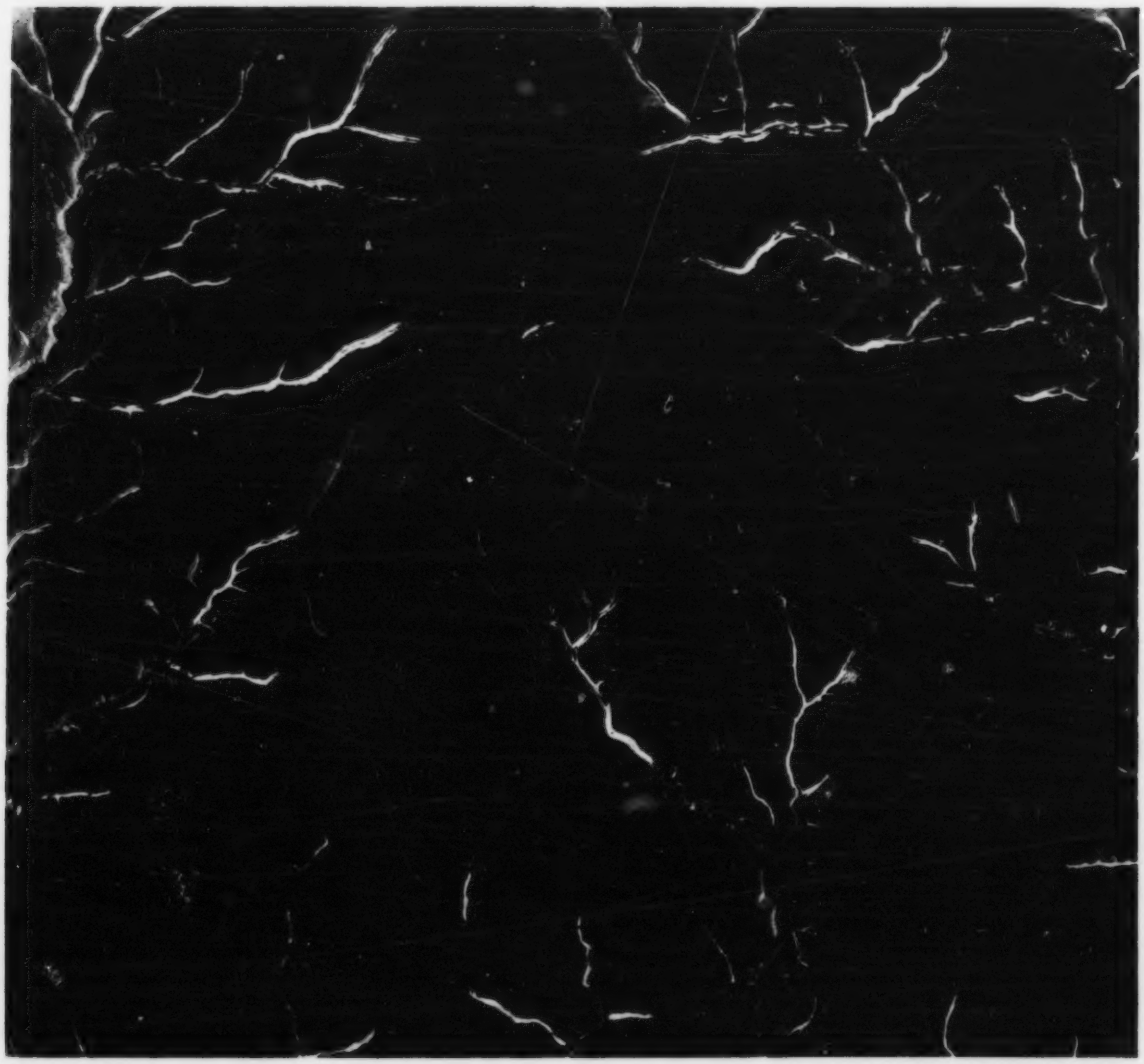

Figure 7. Till units 2a and 2b on southwestern Cornwallis Island. Till 2b appears darker, due to a higher moisture content. NAPL A16175-70.

Marine deposits

Marine deposits almost completely cover the small islands such as Somerville, Milne, Crozier, Baring, and Houston Stewart; mask 20% to 50% of Griffith, Lowther, and Little Cornwallis islands; and completely ring the coast of Cornwallis Island, covering about 10% of the island.

Marine deposits are divided into two types: raised beach deposits (3a) and undifferentiated shore and nearshore deposits that lack distinctive beach features (3b).

Raised beach deposits (3a)

Raised beach deposits (3a) are for the most part underlain by alkaline bedrock. Beaches of unit 3a1 are composed of subangular to subrounded platy carbonate clasts, (5-50 cm in length), more equidimensional cobbles, and gravels with variable amounts of sandy silt and loam. The deposits are generally less than 2 m thick. The height of the ridges (measured in the Resolute Bay area) ranges from 20 cm to nearly 1 m. Flights of beaches rising from 80 to 100 m are best preserved on reworked felsenmeer derived from carbonates, for this coarse material is less susceptible to mass wasting than fine material.

Beaches of unit 3a2 occur in areas where the underlying material is well consolidated alkaline clastic bedrock; these beach deposits have more sand and silt than those over carbonate rock, and the gravels and platy fragments are smaller (rarely greater than 10 cm long). The beach form in unit 3a2 is less well preserved, and continuous beaches rarely extend above 30 m a.s.l.

Shallow ponds may develop in the swales of raised beach deposits, but these are generally ephemeral, for the materials are generally well drained. Ponds persist mainly where the swales rest on bedrock.

Frost cracks, many containing ice wedges, occur on most beach deposits in the study area (Mackay, 1953). In the Resolute area the best developed fissure networks occur above 15-25 m a.s.l. These higher (and older) deposits on Cornwallis Island commonly exhibit some degree of sorting into nets and stripes. Below 15 m both frost cracks and sorting are less well developed.

Undifferentiated nearshore deposits (3b)

In some broad valleys (grabens such as Dyer Cove on Griffith Island, Intrepid Bay and Taylor River grabens on Cornwallis Island) a thin veneer of fine sand and silt masks poorly consolidated sandstone (R1). This veneer is less than 1 m thick and has no distinctive beach features. However, the increase of fines in unit 3b results in greater moisture retention than in the surrounding R1 unit; these areas have a distinctive, nearly continuous vegetation cover. High and low centre polygons and small thermokarst ponds may occur locally.

Fluvial deposits

Fluvial deposits of mappable size are common on Cornwallis Island. The largest occur along the major rivers such as the Ward, Taylor, 'Disappointment', Allen, Eleanor, Abbott, and Mecham. Fluvial deposits are divided into two types: modern floodplain deposits and older terraced deposits.

Modern floodplain deposits (4a)

The modern floodplains of all major rivers of Cornwallis Island consist of stratified coarse carbonate gravels, with varying amounts of sand and silt, assumed to be from several to tens of metres thick. The unit includes broad braided channels and adjacent terraces, which are prone to annual flooding.

Older terrace deposits (4b)

Older terraces of fluvial origin are perched above the modern floodplains. The terraces probably include glaciofluvial outwash and small raised marine deltas. Along Abbott River and along other rivers which drain predominantly carbonate surfaces, gravels form the bulk of the sediments. Along Taylor River, however, sand and silt are more common, for the river has cut through poorly consolidated sandstone.

The thickness of this unit is not known; at Allen River, north of Resolute Bay, coarse sediments are estimated to be 20 m thick, and are at least 10 m thick in the Resolute Bay area.

Older terraces commonly have well developed high and low centre polygons. Within these polygons there may be poorly sorted nets and circles.

Two small sinuous ridges about 5 m high and 0.5 km long occur within areas mapped as unit 4b. One occurs at the mouth of the Abbott River, the other at the mouth of a stream south of Cape Phillips. They consist of stratified coarse gravel and sand of local origin and resemble eskers, but their origin is uncertain because they have been strongly modified by erosion.

Colluvial deposits

Colluvial deposits mantle the lower slopes and valley floors over about 5% of the map area. They are most abundant on the central uplands of Cornwallis Island, and along the cliffed coasts of Cornwallis, Baillie-Hamilton, Lowther, Griffith, and Browne islands. Two general types of colluvial deposits are common: fine grained colluvium (5a) which has an abundance of sand and silt, and talus (5b) which has few or no fines.

Fine grained colluvium (5a)

The lower slopes and valley bottoms of the uplands and part of the Cornwallis Island plateau are mantled with fine grained colluvium derived from the weathered bedrock (1b and 1a2) and possibly from a locally derived till (2a). In these areas

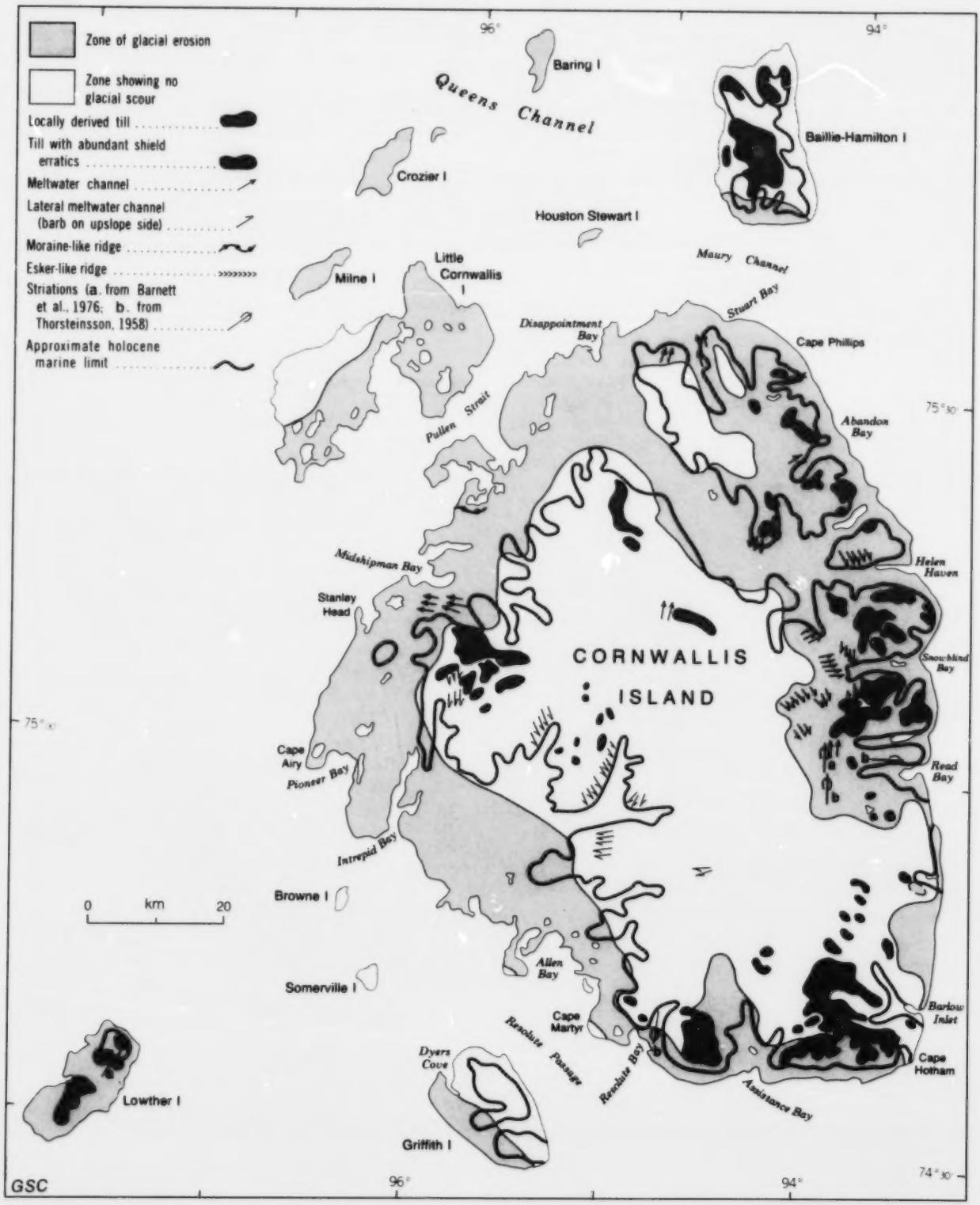

Figure 8. Glacial features in the Cornwallis Island area.

the fine grained sediments have been transported downslope by sheet and rill wash and solifluction, and form blankets which completely mask bedrock structure. This sandy, silty diamicton contains varying amounts of locally derived carbonate gravels which are generally subrounded platy pebbles. Nets and stripes characteristically occur on this unit.

On the low angle slopes of the upland and plateau, the materials are drained by small ephemeral streams which are unable to handle the present sediment load and are choked with sediment. At lower elevations where the slopes are steeper, the streams are larger and better able to handle the sediment load.

The colluvial materials downslope from Signal Hill at Resolute Bay afford good examples of somewhat coarser, sorted colluvium on which massive solifluction lobes have developed. These are estimated to be at least 2.5 m thick at the toe (P.A. Egginton, personal communication, 1983). Wilkinson and Bunting (1975) showed that sheet and rill wash are currently active in the Resolute area, for substantial accumulations of fines occur in catchments placed in rills during periods of runoff.

Talus (5b)

Talus, consisting of coarse slabby rock debris and gravels with a minor amount of fines, has accumulated below steep slopes and scarps. These deposits are common along the east coast of Cornwallis Island, below the cliffs at Cape Martyr, Cape Sheringham, Browne Island, Baillie-Hamilton Island, and Lowther Island. Unit 5b includes the Cape Hotham landslide (Thorsteinsson, 1958) in the southeastern part of Cornwallis Island.

Organic deposits

In the north-central lowland and on fluvial deposits along Disappointment Bay River, and in the Intrepid Bay and Dyer Cove grabens, there are peat deposits at least 1 m thick, which are currently eroding. According to Tarnocai (in Lowdon and Blake, 1979) a peat deposit in the area mapped as unit 2b near Intrepid Bay developed during warmer times, ca. 6500 BP. Peaty mounds also occur locally in the Resolute area (Washburn, 1983).

QUATERNARY HISTORY

Introduction

The landscape of the Cornwallis Island area is essentially of Tertiary or earlier age. The glacial history of the Arctic Islands is poorly understood in this area. Classical glacial landforms, which are common on parts of Somerset Island and Boothia Peninsula, and terrain on the south side of Parry Channel (Dyke, 1983, 1984), are limited in the map area. Several lines of evidence suggest, however, that the area has been glaciated.

Evidence for glaciation and marine transgression during the Quaternary is presented in this section and preliminary interpretation of the data is offered. Good stratigraphic evidence has not been found; most dates on peat, shells, and marine mammal remains, while helping to define marine episodes, rarely relate to definite limits. For the extent and timing of glacial events, reliance is placed on the interpretation of these events in adjacent areas, such as Somerset Island to the south (Dyke, 1983), and Melville Island to the west (Hodgson et al., 1984).

Evidence for glaciation

Several lines of evidence suggest that the Cornwallis Island area has been glaciated: (1) sparsely distributed shield erratics at all elevations on Cornwallis Island (Thorsteinsson, 1958; Barnett et al., 1976, 1977a); (2) two types of till, one of local derivation, and one containing abundant erratics of southern provenance; (3) ice moulded and scoured terrain (in units R1, R2, and R3) around the coast of Cornwallis Island and also on parts of Lowther, Griffith, Little Cornwallis, and Baillie-Hamilton islands; (4) striations on bedrock on Cornwallis and Lowther Islands; (5) U-shaped river valleys along the east coast of Cornwallis Island; (6) cirques along the eastern coastal cliffs between Cape Hotham and Read Bay, Cornwallis Island; and (7) numerous series of lateral meltwater channels on Cornwallis Island.

These glacial features, summarized in Figure 8, suggest that ice from two distinctly different sources affected the area: ice originating to the south and ice originating locally. Other features are of undetermined provenance. These include major ridges of till and ice scoured topography away from the coast.

Although typical glacial landforms are scarce in the Cornwallis Island area, there are a few landforms that may be of glacial origin. A large moraine-like ridge or kame composed of locally derived materials occurs at the neck of a peninsula south of Marshall Peninsula, northwest Cornwallis Island (Fig. 5, 8). The gravels in the ridge contain striated pebbles (D.M. Barnett, personal communication, 1975). The surface of this feature has been reworked into beach deposits.

Moraine-like and esker-like ridges also occur in the Trafalgar Lakes area in south-central Cornwallis Island. These are primarily composed of coarse sand and limestone and dolomite (local) gravel, with striated cobbles (D.M. Barnett, personal communication, 1975, 1977). Some erratics occur, but are not abundant. Ridges of possible glacial origin occur in the north-central lowland, at the mouth of Abbott River, and near Cape Phillips (Fig. 9), Cornwallis Island.

Erratic-bearing glaciomarine-like deposits containing shells have been observed in Mecham River valley (A.L. Washburn, personal communication, 1985).

Buried till with Laurentide erratics has been noted in a section along a tributary to the main river in Dyer Cove, Griffith Island (D.M. Barnett, personal communication, 1975). No areal extent could be traced for they are overlain by colluvium and marine deposits.

Influence of continental ice sheet(s)

Several of the above features suggest that the map area was overrun by northward flowing ice. Ubiquitous scattered igneous and granitic erratics over the entire map area suggest that at some time it was overrun by ice flowing from the Canadian Shield. Similar occurrences of erratics have been reported over most of the Queen Elizabeth Islands (Craig and Fyles, 1960; Barnett et al., 1976) and on Somerset Island (Dyke, 1983).

Other possible origins for these erratics include: sea ice rafting during a complete submergence and (2) remnants of fluvial gravel deposits of Tertiary or younger age on high level erosion surfaces. There is no evidence, however, to suggest that the whole area was submerged; no marine deposits were found above 120 m elevation. Similarly, the origin of erratics as remnants of fluvial gravel deposits is hard to prove or disprove. Although substantial remnants of gravels, resembling the Beaufort Formation and containing abundant southern provenance clasts, do occur on Melville Island

Figure 9. Esker-like ridge near Cape Phillips, Cornwallis Island. NAPL A16175-88.

Table 3. Radiocarbon ages and amino acid ratios from Cornwallis and adjacent islands

Lab no*	^{14}C Age (years BP)	Elevation m a.s.l.	Dated material	Location	Collector	Reference
Radiocarbon dates						
QL-1610	1200 ± 30	56 ± 2	Driftwood	Resolute 74°43'N, 95°00'W	A.L. Washburn	Washburn, 1985
W-1217	5050 ± 350	18 ± 2	Shells	Cornwallis Island 74°42'N, 94°49'W	A.H. Lachenbruch	Blake, 1970
GSC-2532	6590 ± 100	87	Peat	Intrepid Bay 75°22.8'N, 96°09'W	C. Tarnocai	Lowdon and Blake, 1979
GSC-1193	7380 ± 140 7570 ± 140	~50	Whale bone	Cornwallis Island 74°44'N, 94°42'W	F. Muller	Blake, 1970
QL-1760	8220 ± 80	25 ± 3	Shells	Resolute 74°42'N, 94°46'W	A.L. Washburn	Washburn, 1985
GSC-1623	8540 ± 170	70 ± 15	Shells	Cornwallis Island 74°44'N, 94°42'W	J.G. Cogley	Lowdon et al., 1977
W-1220	8550 ± 300	114 ± 2	Shells	Cornwallis Island 74°42'N, 94°48'W	A.H. Lachenbruch	Blake, 1970
QL-1609	8970 ± 30	40 ± 2	Shells	Resolute 74°43'N, 95°01'W	A.L. Washburn	Washburn, 1985
QL-1756	9030 ± 90	83 ± 2	Shells	Resolute 74°44'N, 94°59'W	A.L. Washburn	Washburn, 1985
QL-1754	9070 ± 70	56 ± 1	Shells	Resolute 74°44'N, 95°00'W	A.L. Washburn	Washburn, 1985
QL-1762	9090 ± 90	73 ± 6	Shells	Resolute 74°43'N, 94°43'W	A.L. Washburn	Washburn, 1985
QL-1763	9160 ± 70	65 ± 3	Shells	Resolute 74°43'N, 94°43'W	A.L. Washburn	Washburn, 1985
QL-1755	9200 ± 90	67 ± 2	Shells	Resolute 74°45'N, 95°00'W	A.L. Washburn	Washburn, 1985
QL-1753	9260 ± 70	64 ± 2	Shells	Resolute 74°44'N, 95°01'W	A.L. Washburn	Washburn, 1985
QL-1761	9290 ± 90	79 ± 6	Shells	Resolute 74°43'N, 94°43'W	A.L. Washburn	Washburn, 1985
QL-1759	9390 ± 90	59 ± 2	Shells	Resolute 74°45'N, 94°58'W	A.L. Washburn	Washburn, 1985
GSC-322	9470 ± 150	113-119	Shells	Lowther Island 74°33'N, 97°31'W	W. Blake, Jr.	Lowdon et al., 1967
QL-1764	9560 ± 90	102 ±	Shells	Resolute 74°42'N, 94°49'W	A.L. Washburn	Washburn, 1985
QL-1612	9610 ± 40	102 ± 2	Shells	Resolute 74°44'W, 94°57'W	A.L. Washburn	Washburn, 1985
QL-1751	9690 ± 90	113 ± 2	Shells	Resolute 74°43'N, 94°52'W	A.L. Washburn	Washburn, 1985
QL-1752	27 300 ± 600	205 ± 3	Shells	Resolute 74°42'N, 94°50'W	A.L. Washburn	Washburn, 1985
QL-1757	27 800 ± 500	162 ± 3	Shells	Resolute 74°41'N, 95°04'W	A.L. Washburn	Washburn, 1985
QL-1750	32 000 ± 900	158 ± 3	Shells	Resolute 74°41'N, 95°04'W	A.L. Washburn	Washburn, 1985
QL-1611	>60 000	144 ± 2	Wood	Resolute 74°44'N, 94°56"W	A.L. Washburn	Washburn, 1985
Amino acid ratios and projected dates						
AAL-359	Combined 0.056, 0.06 Age >40 000	168	*Hiatella arctica*	Cape Martyr Cornwallis Island 74°40'N, 95°04'W	D.M. Barnett and S.A. Edlund	this report
AAL-1503	Total -a 0.11 -b 0.13 -c 0.10 Free -a 0.69 -b 0.76 -c 0.03 Age >100 000	220 ± 5	*Hiatella arctica*	Cornwallis Island 74°41'N, 94°00'W	D.M. Barnett, S.A. Edlund, and L.A. Dredge	this report

* Dating Laboratories

AAL - Amino Acid Laboratory, INSTAAR, University of Colorado
GSC - Geological Survey of Canada Radiocarbon Laboratory
QL - Quaternary Laboratory, University of Washington
W - US Geological Survey, Reston, Virginia

(Hodgson et al., 1984) and possibly on Bathurst Island (Barnett et al., 1977b), little evidence was found to suggest that such gravels were deposited in the Cornwallis Island area. All in all, a glacial origin for the erratics seems likely.

Unlike the till of local origin that contains few scattered erratics (unit 2a), there appears to be more than one erratic-bearing till (unit 2b). The erratic-bearing till is restricted to the plateau on southeastern Cornwallis Island and to Lowther Island; the ages of these tills appear to be different, with the older being on Cornwallis Island where the deposits have been subjected to severe mass wasting so that they form an entirely featureless landform. Amino acid racemization of shell fragments from this till (unit 1b) on Cornwallis Island were interpreted by G.H. Miller (personal communication, 1978) as being greater than 100 000 years old (Table 3).

The erratic-bearing till (unit 2b) on Lowther Island has the least weathered 'freshest' appearance of all tills in the Cornwallis Island area (Barnett et al., 1976). Striae in the vicinity of this till indicate ice movement to the northeast (N10°E).

Since the largest zones of ice scour are on the southern sides of the low lying islands and on the southern coastal areas of Cornwallis and Little Cornwallis islands, the most likely direction of ice movement was northwards. In addition, the features resembling roche moutonnée observed in the Read Bay area by Thorsteinsson (1958) also indicate northward movement of ice along the eastern coast of Cornwallis Island.

It is impossible, however, to rule out completely the possibility that much of the coastal ice scour (Fig. 6, 8) was produced by local ice caps on Cornwallis Island. Dyke (1983) showed that both local ice caps and Laurentide ice were responsible for ice scour on Somerset Island. Perhaps a combination of ice from both local and foreign sources is responsible for ice scour in the area.

Influence of local ice cap(s)

Local glaciation is evidenced by numerous U-shaped valleys along the eastern coast of Cornwallis Island, which have been carved by ice moving from the centre of the island (Thorsteinsson, 1958), and by the till that consists of locally derived materials only, on the plateau and central upland surfaces of Cornwallis and Baillie-Hamilton islands. Such a till appears, from air photo interpretation, to underlie an erratic-bearing till (unit 2b) on southeastern Cornwallis Island (Fig. 5), although no stratigraphic section was found to confirm this.

Local glaciation left no basal erosional or flow features in the central part of Cornwallis Island, for the extensively weathered bedrock mantle (unit 1b) remains undisturbed except for ice marginal channels described below. This suggests that a local ice cap was frozen to the surface over much of the Island. At its margin, which appears to have extended at least to the present coastline, the ice was more erosive and was probably responsible for some, if not all, of the ice scour at the periphery of Cornwallis Island, especially in the northern and eastern parts of Cornwallis Island and in the north-central lowland. Thorsteinsson (1958) and Barnett et al. (1976) reported striations near Resolute Bay and Read Bay that confirm a radial ice movement offshore.

Abundant meltwater channels, most of which appear to be lateral channels, occur on both sides of Taylor River graben, on south-facing slopes of the west-central upland, and in the vicinity of Snowblind Creek and Eleanor River. These channels show a retreat pattern of ice tongues and fronts towards the central uplands.

Cirque glaciers also developed along the eastern coast of Cornwallis Island between Barlow Inlet and Read Bay. Whether these isolated glaciers were coeval with the local ice caps is not known.

Postglacial emergence

Holocene emergence

Beach deposits, erosional features of probable marine origin, and marine mammal and mollusc remains at elevations above present sea level (Table 3) indicate that much of the coastal area has emerged from the sea. The highest beach ridges in the map area occur on Lowther Island where Blake (in Lowdon et al., 1967) measured beaches at approximately 106 m. On Cornwallis Island the highest beach ridges occur at about 100 m on the southern and western coasts and on Baillie-Hamilton Island at about 80-90 m on the north coast. Some of the low lying islands in McDougall Sound and Resolute Passage are covered with beach deposits (Fig. 5).

Washburn (1985) collected Holocene shells at 102 and 113 m in the Resolute area (Table 3). These mark the highest Holocene sea level thus far recorded on the island. A washing limit of approximately 120 m on west-central Cornwallis Island may relate to this event.

The early Holocene, ca. 9700 to 8000 BP, seems characterized by a rapid emergence with over half of total emergence occurring during this period (Fig. 10). This pattern of emergence is similar to that of Somerset Island to the south (Dyke, 1978a,b, 1983), where deglaciation began ca. 9300 BP. Blake (1975) showed a similar pattern of rapid emergence in the early Holocene at Cape Storm, Ellesmere Island. Few data are available about the later Holocene emergence of the area. Is it assumed that the rate of emergence slowed after about 6000-5000 BP.

Earlier emergence

There is some evidence of an earlier sea which extended to higher elevations than that of the Holocene marine event. Amino acid racimization (G.H. Miller, personal communication, 1978) indicates that shells collected by D.M. Barnett and myself at Cape Martyr were greater than 40 000 years old (Table 3). In the same area ^{14}C dates on shells are 27 800 ± 500 BP and 32 000 ± 900 BP (QL-1757 and QL-1750; Washburn, 1985) and dates on samples from Signal Hill have an age of 27 300 ± 600 BP (Table 3). Both Dyke (1979, 1983) and Hodgson et al. (1984) have described a higher and older marine transgression on Somerset Island and Dundas Peninsula, Melville Island, respectively.

Figure 10. Holocene emergence in the Resolute area. Note the distinct fights of beach ridges up to ca. 100 m a.s.l. NAPL A16666-21.

Discussion and summary

The earliest and most extensive Quaternary or older event seems to be the weathering of bedrock, which produced widespread residual and colluvial deposits. Glaciation played a relatively minor role in shaping the landscape. Thin till veneer occurs locally on some of the islands, and ice scoured some of the coastal terrain.

At least two episodes of Laurentide glaciation occurred during the Quaternary, but as yet no age can be assigned to them. A very early event of Laurentide glaciation was responsible for deposition of erratic-rich till on the southeastern plateau of Cornwallis Island. Evidence for perhaps this or another early glacial event lies in the scattered Precambrian Shield erratics that occur over the entire map area. Dyke (1983) suggested that the distribution of high level erratics dated to the Early Wisconsinan; however, it may be even older. It is impossible to say whether these deposits record separate glaciations.

An early Laurentide glaciation may be responsible for the ice scouring of parts of Cornwallis Island and the adjacent islands in McDougall Sound, and also for similar features on southern Bathurst and southwestern Devon Island. This erosion, however, may have been caused by local ice.

The last (probably Late Wisconsinan) Laurentide glaciation appears to have affected only Lowther Island, which has the 'freshest' till with abundant shield erratics; no similar till occurs in the rest of the area, including adjacent Griffith Island directly to the northeast. Striae confirm ice movement from the southwest, possibly from the M'Clintock Ice dome (Dyke et al., 1982).

The maximum limit of this most recent Laurentide Ice Sheet seems to lie in Barrow Strait, between Lowther Island and southwestern Cornwallis and Griffith islands (Fig. 8, 11). Ice scoured terrain on southwestern Griffith Island could have been produced at this time, but probably was carved by ice at an earlier time.

In earlier works Jenness (1952) and Craig and Fyles (1960) suggested that the Late Wisconsinan glacial limit was far to the south of Cornwallis Island (Fig. 11). Prest et al. (1968), however, included Lowther Island within the limit of the Late Wisconsinan ice margin and tentatively placed the limit between Lowther and Griffith islands, although at the time Prest et al. had no field data to confirm this (V.K. Prest, personal communication, 1983). This report supports this part of their glacial limit.

Evidence from adjacent areas, however, shows that the limit does not seem to reach Lancaster Sound, as Prest postulated. Dyke (1983) drew a Late Wisconsinan limit on southern and western Somerset Island (Fig. 11). When Dyke's ice gradients are extended northwards, it appears unlikely that Late Wisconsinan ice would have touched Cornwallis Island, let alone have had sufficient strength to cover it and cause ice scour in the coastal areas. These gradients, however, are quite consistent with Lowther Island being within the Late Wisconsinan ice limit.

Local ice caps were present on Cornwallis Island, and possibly Baillie-Hamilton Island, during Wisconsinan time, perhaps several times, corresponding to episodes of regional glaciation.

At its maximum a local ice cap appears to have extended at least to the perimeter of Cornwallis Island and perhaps to some of the adjacent islands, and it may be responsible for ice scour on them. Dyke (1983) showed similar local ice cap development on Somerset Island and attributed much of the ice scour on northern and eastern Somerset Island to local ice. This may also be the case on Cornwallis Island.

The most recent Laurentide glaciation was followed by emergence of the land to about 106 m on Lowther Island (Blake in Lowdon et al., 1967), roughly 100-110 m on southern Cornwallis Island, and less than 90 m on northern Cornwallis and Baillie-Hamilton islands. Extensive, continuous flights of raised beaches confirm this emergence.

Blake (1970) postulated that an extensive Innuitian Ice Sheet covered the Queen Elizabeth Islands during the Late Wisconsinan, and that this ice sheet is responsible for crustal depression in the Queen Elizabeth Islands. Prest et al. (1968) showed the southern boundary of this northern ice sheet as being coincident with the northern limit of Laurentide ice.

The limited evidence from Cornwallis Island does not confirm the presence of an Innuitian Ice Sheet in the south-central Queen Elizabeth Islands. Hodgson (1978) suggested that cold-based, local ice caps may have ringed the perimeter of Norwegian Bay from northern Bathurst and Devon islands to Axel Heiberg and Ellesmere islands during the Late Wisconsinan. Dyke (1983) also reported a local ice cap on Somerset Island during the Late Wisconsinan. Since elevations on the height of land of Cornwallis Island are similar to those on Somerset, and meltwater channels suggest retreat of ice towards the highlands, Cornwallis Island most likely had an ice cap as well. The combined loading of these individual ice caps, some of which may have coalesced at their maximum, as well as the effects of Laurentide ice immediately to the south, may be responsible for the regional crustal depression.

The suggestion of several episodes of Laurentide ice also has its counterpart in the western Queen Elizabeth Islands. Hodgson et al. (1984) showed that Laurentide ice covered parts of southern Melville Island several times during the Quaternary. In their model, the most recent (Late Wisconsinan?) ice margin, which only lapped onto southern Dundas Peninsula in the Winter Harbour area and onto southern Byam Martin Island (Hodgson and Vincent, 1984), lies south of the maximum extent of Laurentide glaciation. Therefore the model postulated for the Cornwallis Island area is consistent with the regional model, in which the most recent episode was not the most extensive glaciation.

The absence of good stratigraphic sections, datable materials, and indications of direction of ice movement makes the understanding of the Quaternary history of the Cornwallis Island area tenuous. More detailed studies of sections in the Eleanor River area (around sites 171, 172, and 173) and on

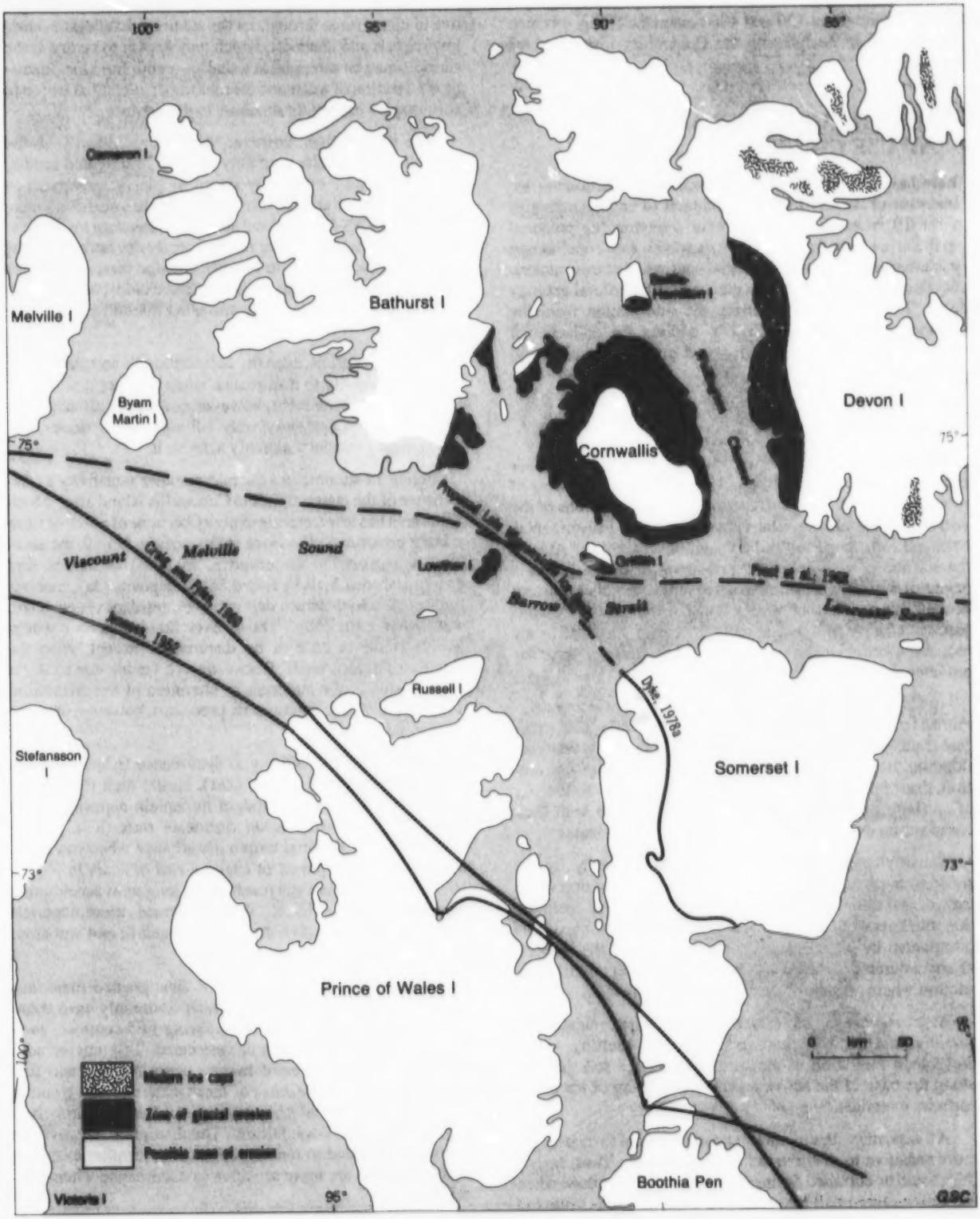

Figure 11. Proposed Late Wisconsinan ice limits and zones of glacial erosion.

Griffith Island (sites 150 and 156 Appendix 1, Fig. 14) may prove useful in deciphering the Quaternary history of the region.

ECONOMIC GEOLOGY AND LAND USE CONCERNS

There have been increasing demands for predictions or assessments of the environmental impacts of various activities in the High Arctic to assist route selection for potential pipelines and roads, to minimize travel and construction problems, and to identify potential sources of borrow materials. Such information can be gleaned from surficial geology data. This section summarizes the information from the previous sections in an effort to address the concerns of terrain sensitivity, trafficability, and potential of sand and gravel resources.

Terrain sensitivity

Terrain sensitivity, as used here, refers to the ability of soil or surface materials to stabilize and recover from the effects of vehicle travel. In their frozen state (nine to ten months of the year) all materials are relatively insensitive to disturbance, although some crushing and compaction can occur. Also, if the surface is modified by the removal or disruption of a vegetation cover, erosion may be initiated when thawing occurs. The effects of winter activities in creating disturbance during the following summers can be minimized by the use of buffering pads of snow for vehicle traffic and for the movement of heavy equipment.

In summer, terrain damage generally results from one or more of the following: the acceleration of geomorphic processes, the interruption of natural drainage (with resultant flooding, desiccation, or channelling), wind and water erosion, slope failure, and thermokarst development. Sensitivity of surficial materials to disturbance varies both with their composition and with the time and type of disturbance.

Sensitivity to disturbance is controlled chiefly by the shear strength of the soil which in turn is a function of its texture and structure, moisture content, degree of cementation, thickness and degree of compaction. Fine grained soils (dominated by silt and clay sized particles) are the weakest of any saturated material as a result of loss of grain to grain friction where particles become separated by water.

Sources of water that influence the moisture content of the surficial materials include precipitation, melting snow, downslope migration of moisture through the soil (usually along the base of the active layer), and melting of ice in the surficial materials.

All deposits with a significant component of fines become more sensitive to disturbance when saturated. Thus, activities should be curtailed during such times as spring thaw when the active layer in all but snowfree areas becomes saturated and during summer after heavy rain or snow. Some areas, such as wetlands and places directly downslope from permanent and semi-permanent snowbeds, remain extremely sensitive to disturbance throughout the summer. In addition, shallow runnels and channels, which may appear to be dry at the surface, may be saturated at a shallow depth from the downslope migration of water and the melting of interstitial ice; such sites may be extremely sensitive to disturbance.

The wettest sites, however, may not necessarily be the most sensitive. While a rut may develop in saturated terrain, the wet soil may eventually return by plastic movement to roughly the same general configuration as before disturbance. "Soft" materials (fine grained soils with abundant moisture at the base of the active layer but frequently dry at the surface) may be more sensitive to disturbance, for these may never return to their former shape but retain the deformation which leads to channelling of water and other disruptions of drainage patterns.

All wet materials, even the vulnerable silts and clays, have a lower sensitivity to disturbance when they are dry. In this High Arctic environment, however, few materials achieve a state of complete dryness; only hill tops, upper slopes, and beach ridge crests ocassionally achieve it.

Figure 12 summarizes the mid-summer sensitivity to disturbance of the materials of the Cornwallis Island area. Much of the area has low terrain sensitivity because of a lack of fines and the proximity of bedrock to the surface. Unit 0, the areas least sensitivity to disturbance, includes carbonate and evaporite bedrock (R3), raised beach deposits (3a), coarser fractions of older terrace deposits (4b), residual veneer (1b), and coarse talus (5b). Travel over these materials would likely result in little or no disturbance except when the materials are saturated. Tracks may be visible due to slight compression of the materials or alteration of the orientation of surface pebbles; geomorphic processes, however, are generally unaffected.

Unit 1, where sensitivity to disturbance is low, includes fine grained residual veneer (1a1), clastic rock (R2), some locally derived till (2a), modern floodplain deposits rich in fines (4a), and wetlands on carbonate rock (R3). These materials show minimal terrain disturbance when traversed, usually the development of shallow ruts or scars in places. Normally this should not result in the long term acceleration of geomorphic processes. When saturated, these materials are much more sensitive than those of unit 0; and wet areas of 1 should be avoided at all times.

Unit 2 includes some areas of fine grained materials, usually silty loam or sandy silt which commonly have abundant moisture at the frost table during mid-summer, even though the upper layers may be desiccated. This unit includes till (2a, 2b), fine grained marine deposits (3b), and fine colluvium (5a). Disturbance of these materials may result in local acceleration of channelling, solifluction, and thermokarst or minor slope failure. The disruption, however, is generally confined to the immediate site. Similar to unit 1, these materials are more sensitive to disturbance when saturated.

Unit 3 includes the wettest fines occurring on lower slopes and along valley floors. Large areas occur in fine grained colluvium (5a) and unconsolidated clastic rock (R1); smaller

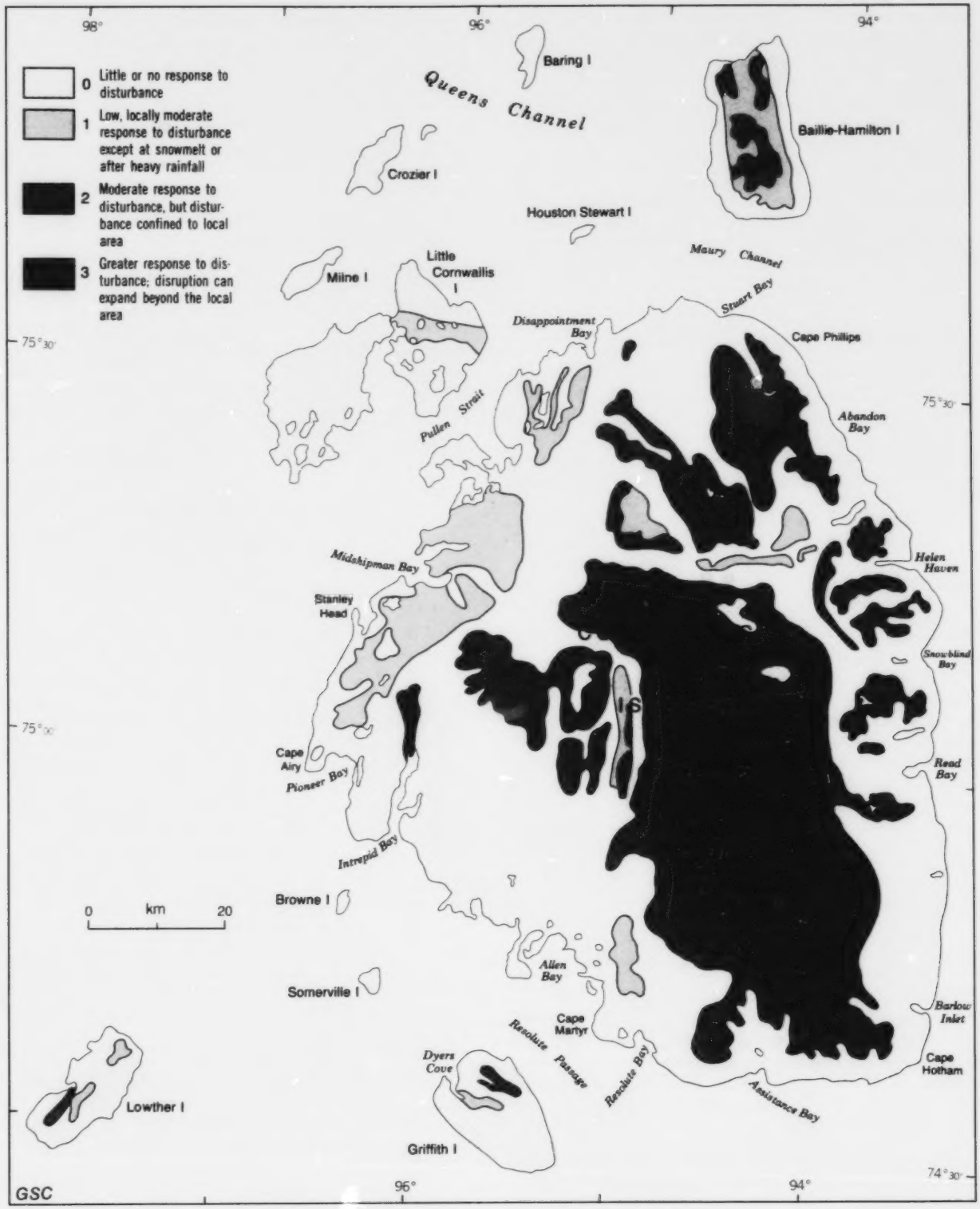

Figure 12. Mid-summer sensitivity to disturbance of the surficial materials.

areas are found at the base of most slopes where fines are common. These materials generally have high moisture contents from the migration of water downslope and from the melting of ice lenses in the active layer. Disturbance could result in increased sheet wash, erosion, solifluction, and slope failure, which could extend beyond the local area.

Although unit 3 is the most sensitive to disturbance in the Cornwallis Island area, the island is one of the least sensitive of the High Arctic Islands. Far more sensitive materials occur on Melville Island (weathered shales such as Cretaceous Kanguk and Christopher formations and marine silt and clay; Barnett et al., 1975) and in the Sverdrup group (Hodgson, 1982).

Vegetation and geomorphic processes

Less than 5% of the study area has continuous vegetation and less than half of that has a bryophytic mat which is sufficiently developed to insulate the underlying materials. Continuous vegetation occurs predominantly in lowland areas and downslope from snowbeds. The remaining communities with continuous cover consist of dwarf shrub and herb tundra with a shallow moss and patina lower stratum (Edlund, in press). Therefore, only a small part of the Cornwallis Island area is vulnerable to the acceleration of geomorphic processes by the disruption of the vegetation cover. Such areas should be easily avoidable.

Where continuous vegetation occurs, however, it does inhibit wind and water erosion of the underlying surficial materials, and well developed root systems, such as those of some herbs and shrubs, may retard downslope movement. Wetland vegetation with sedge and graminoid components, as well as a nearly continuous bryophytic mat, effectively retards thawing of the active layer in summer. On some wetlands the active layer is only 10 cm thick; however, the average is 20 to 30 cm compared to an average thaw depth of approximately 50 cm on unvegetated materials. Thus removal of vegetation would increase the depth of thaw and promote acceleration of thermokarst. Wetland communities found directly downslope from snowbeds commonly stabilize potentially mobile slopes, and disruption of vegetation could result in accelerated erosion or slope failure.

Trafficability

Trafficiability, a measure of the ease with which vehicles can traverse the terrain, is another concern of resource developers. Factors that influence trafficability in the Cornwallis Island area include the bearing strength and shear strength of the surficial material, slope angle, and surface roughness, including major barriers such as cliffs or ravines and smaller barriers such as terrace scarps.

Travel is generally easiest during winter, because the frozen ground eliminates bearing strength problems. Snowbeds may smooth minor surface irregularities. Cliffs and ravines are the major terrain deterrents to winter travel, and they can be avoided by careful planning (Fig. 13).

In summer, trafficability varies with the types of surficial materials and their moisture content. Materials with components of silt and clay have low bearing strength when wet. Residual blankets (1b), fine grained colluvium (5a), morainal deposits (2a, 2b), and some areas of clastic rocks (R1, R2) are included in unit 2 (areas of difficult travel due to low bearing strength). When moist, these soils allow wheeled and tracked vehicles to sink in readily to depths of 5 to 30 cm or more, and it is difficult to maintain traction as these materials readily change from a semi-solid to a liquid state.

Travel over somewhat coarser materials that still have a substantial component of fines, such as in raised beach deposits derived from consolidated clastic rocks (3a2) and residual veneers (4a), is somewhat easier (rated 1) for in these materials the bearing strength is not as low, but they have sufficient fines to cause problems when they are wet. Only the coarsest materials, such as carbonate rocks (R3), beaches derived from carbonates (3a1), residual veneer derived from carbonates (1a), and fluvial deposits (4a, 4b), show little if any bearing strength problems (unit 0). As a general rule, any deposit containing silt and clay has low bearing strength when wet.

Travel can also be impeded by surface roughness. Terrace scarps in fluvial deposits (4a, 4b) may make travel at right angles to a stream difficult. The irregular surfaces of flights of raised beaches (3a), especially on relatively steep slopes, may make travel transverse to the strandlines difficult. Well dissected and ice scoured terrain, with minor outcrops, may have a degree of roughness that warrants careful planning to avoid difficulty. Slope angles in the Intrepid Bay and Taylor River grabens, as well as in other grabens, make travel across these areas difficult. Travel may be easy in some directions but much more difficult in others; such difficulties are included in units 1 or 2, depending on the degree of impediment.

Areas with cliffs and deep ravines are the only areas where travel is difficult to impossible (unit 3). They occur mostly along the east coast of Cornwallis and Griffith islands, and on most of the coast of Baillie-Hamilton and Browne islands.

In summary, most of Cornwallis Island is readily traversible if care is taken in selecting the route – avoiding wet areas, areas with abundant fines, irregular terrain, and cliffs and scarps. In addition, avoidance of travel during and immediately after spring thaw and heavy precipitation in summer will make travel easier.

Sand and gravel resources

The Cornwallis Island area has two types of borrow resources – readily available gravel, which is abundant near the coast of all islands and where frost shattered rock litters the surface, and sand, which has a more restricted distribution.

Gravel

Substantial gravel deposits in the Cornwallis Island area occur in fluvial deposits (4a, 4b), and raised beaches (3a1, 3a2) which together make up about 20% of the study area.

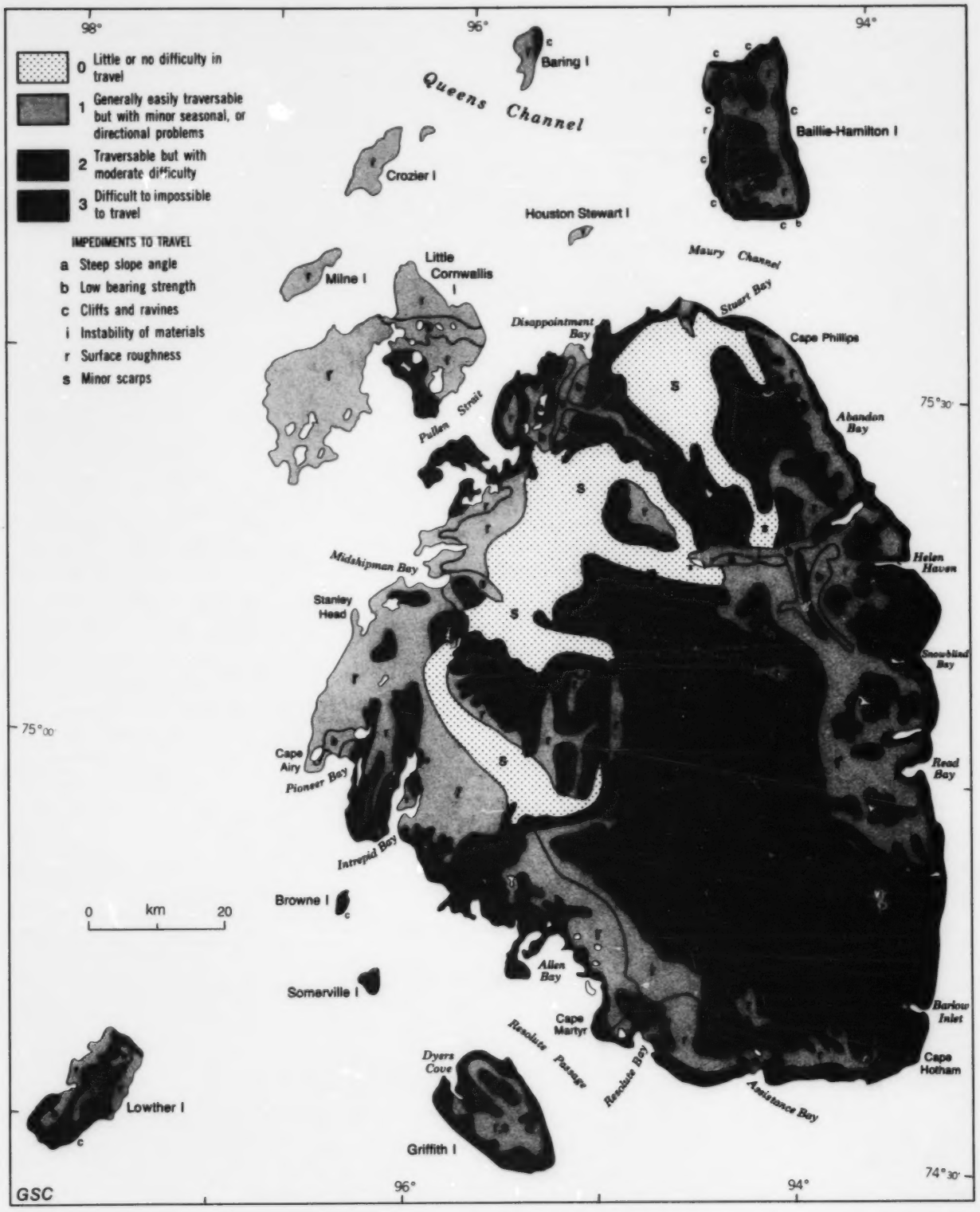

Figure 13. Mid-summer trafficability of the surficial materials.

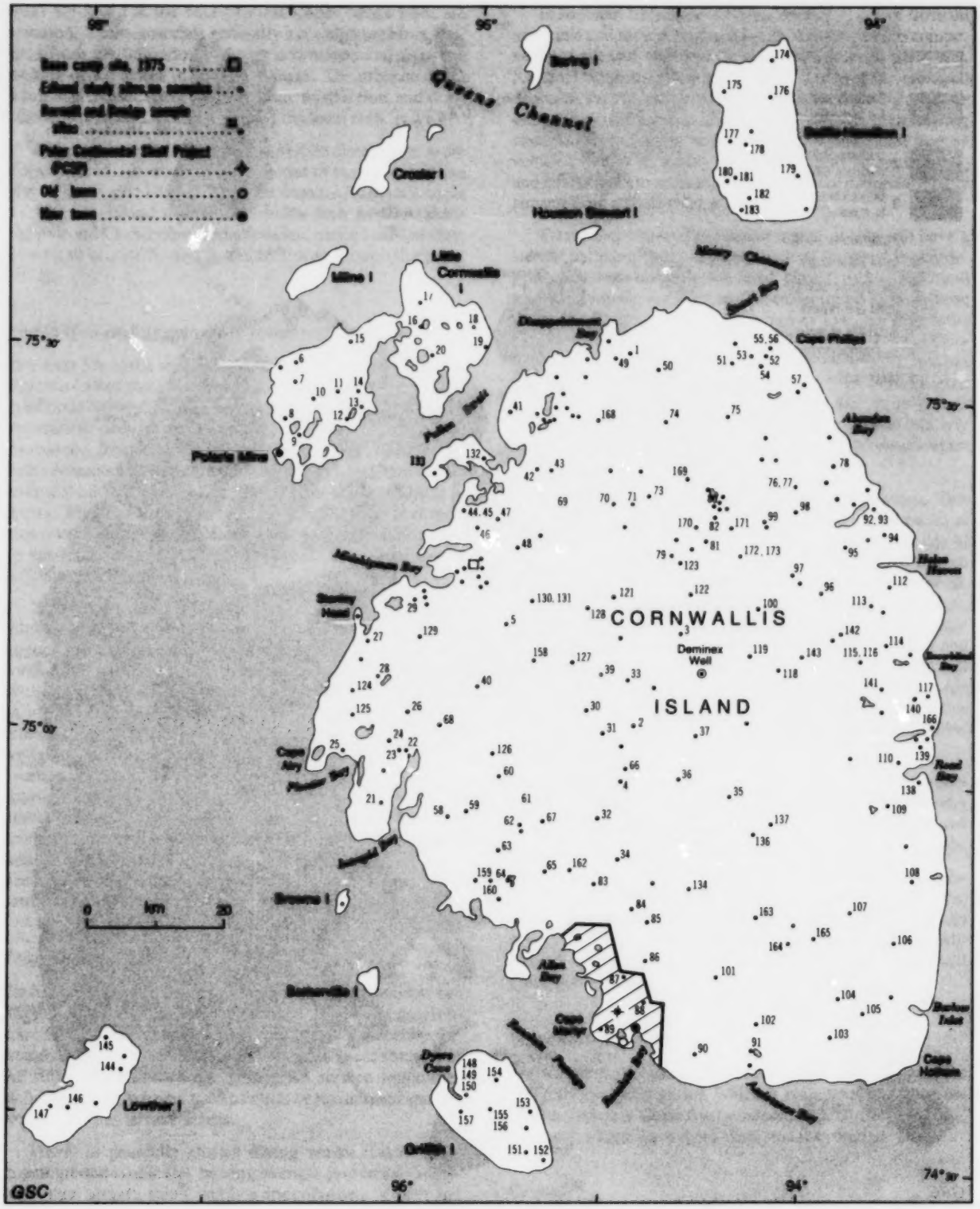

Figure 14. Location of sample sites in the Cornwallis Island area.

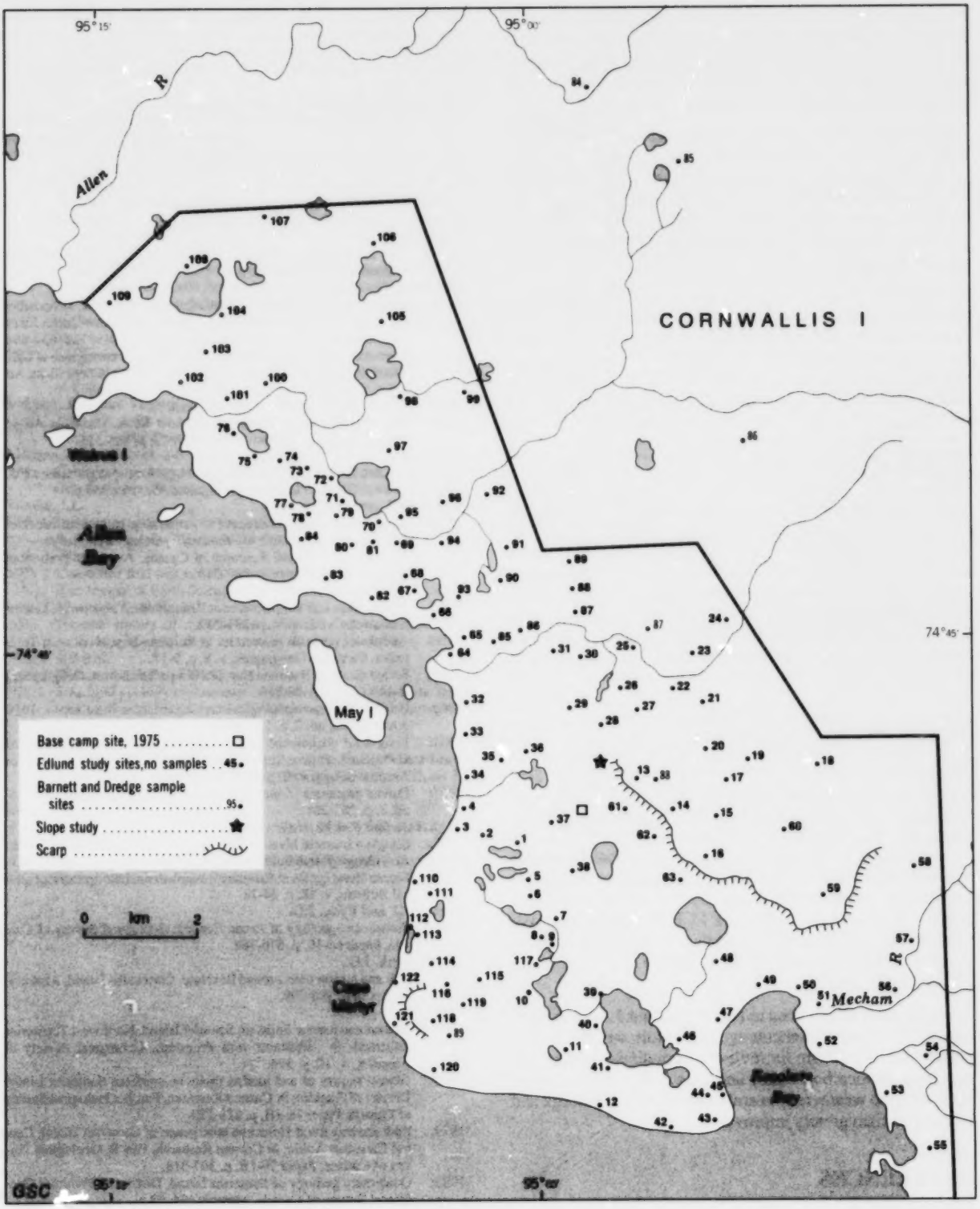

Figure 14. (cont'd)

Carbonate-derived beach deposits are the largest ready source of gravel. Gravels are cleanest where beaches are composed of platy carbonate clasts or more equidimensional cobbles with few fines (3a1); R2 and 3a2 are generally composed of poorly washed aggregate ranging from silt to gravel.

Almost half the fluvial deposits presently occur in active channels (4a); the rest are in raised terraces (4b). The quality of gravel varies from interbedded gravel, sand, and silt (in areas where materials are partially derived from sandstone, siltstone, and shale) to carbonate cobbles and boulders with few fines. At Resolute Bay, coarse fluvial deposits are a major source of gravel.

Although a thin veneer of coarse rock fragments masks the carbonate bedrock surface (1a2), these deposits are less than 1 m thick and are not a ready gravel source. However, the entire area underlain by carbonates can be looked on as a potential gravel resource, for the carbonates can be readily converted into quarry aggregate and riprap by blasting and crushing.

Sand

Thick sand deposits make up less than 5% of the map area and occur only where the weathered Devonian Hecla Bay sandstone, a sandy facies of the Snowblind Bay Formation, and remnants of the Cretaceous-Tertiary Eureka Sound sandstone (R1) occur, mainly in the major grabens of Cornwallis and Griffith Islands. Most deposits of sand and gravel lie in the north-central lowland consolidated clastic rock (R2) and carbonate rock and evaporite (R3) units, but these deposits are not well sorted.

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REFERENCES

Atmospheric Environment Service
1982: Canadian climate normals: The North-Y.T. and N.W.T., Temperature and Precipitation, 1951-1980; Environment Canada, Downsview, Ontario, 55 p.

Barnett, D.M., Edlund, S.A., Dredge, L.A., Thomas, D.C., and Prevett, L.S.
1975: Terrain classification and evaluation, eastern Melville Island, N.W.T.; Geological Survey of Canada, Open File 252, 1318 p., 3 maps.

Barnett, D.M., Dredge, L.A., and Edlund, S.A.
1976: Terrain inventory: Bathurst, Cornwallis and adjacent islands, Northwest Territories; in Report of Activities, Part A, Geological Survey of Canada, Paper 76-1A, p. 201-204.
1977a: Terrain characterization: Cornwallis and adjacent islands, Northwest Territories; Geological Survey of Canada, Open File 457.
1977b: Terrain characterization: Bathurst and adjacent islands, Northwest Territories; Geological Survey of Canada, Open File 479.

Bird, J.B.
1967: The Physiography of Arctic Canada; The John Hopkins Press, Baltimore, Maryland, 336 p.

Blake, W., Jr.
1970: Studies of glacial history in Arctic Canada. I. Pumice, radiocarbon dates and differential postglacial uplift in the eastern Queen Elizabeth Islands; Canadian Journal of Earth Sciences, v. 7, p. 634-664.
1975: Radiocarbon age determinations and postglacial emergence of Cape Storm southern Ellesmere Island, Arctic Canada; Geografiska Annaler, v. 57A, p. 1-71.

Bornhold, B.D., Monahan, D., and Finlayson, N.
1976: Submerged drainage patterns in Barrow Strait, Canadian Arctic; Canadian Journal of Earth Sciences, v. 13, p. 305-311.

Cogley, J.G.
1975: Properties of surface runoff in the High Arctic; unpublished PhD thesis, McMaster University, Hamilton, Ontario, 358 p.

Cogley, J.G. and McCann, S.B.
1975: Surface runoff characteristics of an Arctic nival catchment, Mecham River, Cornwallis Island; *in* Canadian Hydrology Symposium— '75 Proceedings; National Research of Canada, Associate Committee on Hydrology, Ottawa, p. 282-288.

Cook, F.A.
1955: Near surface soil temperatures at Resolute Bay, Northwest Territories; Arctic, v. 9, no. 4, p. 237-249.
1956: Additional notes on mudcircles at Resolute Bay, Northwest Territories; Canadian Geographer, v. 8, p. 9-17.
1958: Sorted circles at Resolute Bay, Northwest Territories; Geographical Bulletin v. 11, p. 78-81.
1960: Periglacial-geomorphological investigations at Resolute — 1959; Arctic, v. 13, no. 2, p. 132-135.
1961: Periglacial phenomena in Canada; *in* Geology of the Arctic, ed. G.O. Raash; Proceedings of the First International Symposium on Arctic Geology, v. II, p. 768-780.
1967: Fluvial processes in the High Arctic; Geographical Bulletin, v. 9, no. 3, p. 262-268.

Cook, F.A. and Raiche, V.G.
1962a: Simple transverse nivation hollows at Resolute, Northwest Territories; Geographical Bulletin, v. 18, p. 79-85.
1962b: Freeze-thaw cycles at Resolute, Northwest Territories; Geographical Bulletin, v. 18, p. 64-78.

Craig, B.G. and Fyles, J.G.
1960: Pleistocene geology of Arctic Canada; Geological Survey of Canada, Paper 60-10, p. 676-764.

Cruickshank, J.G.
1971: Soil and terrain units around Resolute, Cornwallis Island; Arctic, v. 24, no. 3, p. 195-209.

Dyke, A.S.
1978a: Glacial and marine limits on Someset Island, Northwest Territories (abstract); *in* Abstracts with Programs, Geological Society of America, v. 10, p. 394.
1978b: Glacial history of and marine limits on southern Somerset Island, District of Franklin; *in* Current Research, Part B, Geological Survey of Canada, Paper 78-1B, p. 218-223.
1979: Radiocarbon-dated Holocene emergence of Somerset Island, Central Canadian Arctic; *in* Current Research, Part B, Geological Survey of Canada, Paper 79-1B, p. 307-318.
1983: Quaternary geology of Somerset Island, District of Franklin; Geological Survey of Canada, Memoir 404, 32 p.
1984: Quaternary geology of Boothia Peninsula and northern District of Keewatin, central Canadian Arctic; Geological Survey of Canada, Memoir 407, 26 p.

Dyke, A.S., Dredge, L.A., and Vincent, J.S.
1982: Configuration and dynamics of the Laurentide Ice Sheet during the Late Wisconsin maximum; Géographie physique et Quaternaire, v. XXXVI, no. 1-2, p. 5-14.

Dyke, L.D.
1981: Bedrock heave in the central Canadian Arctic; *in* Current Research, Part A, Geological Survey of Canada, Paper 81-1A, p. 157-167.

Edlund, S.A.
in press: Vegetation of Cornwallis and adjacent islands, Northwest Territories; Geological Survey of Canada, Paper.

Egginton, P.A.
1972: Observations on patterned ground phenomena found on Cornwallis Island, N.W.T.; unpublished BA thesis, McMaster University, Hamilton, Ontario, 158 p.

Hodgson, D.A.
1978: Absence of Late Quaternary glacial features on the Ringnes and adjacent islands, Arctic Archipelago (abstract); Joint annual meeting, Geological Association of Canada, Mineralogical Association of Canada, and Geological Society of America, Toronto, Proceedings, v. 10, no. 7, p. 422.
1982: Surficial materials and geomorphological processes, western Sverdrup and adjacent islands, District of Franklin; Geological Survey of Canada Paper 81-9, 44 p.

Hodgson, D.A. and Vincent, J.S.
1984: A 10 000 yr BP extensive ice shelf over Viscount Melville sound, Arctic Canada; Quaternary Research, v. 22, p. 18-30.

Hodgson, D.A., Vincent, J-S., and Fyles, J.G.
1984: Quaternary geology of central Melville Island, Northwest Territories; Geological Survey of Canada, Paper 83-16, 25 p. + map 1538A.

Jenness, J.L.
1952: Problem of glaciation in the western islands of Arctic Canada; Bulletin of the Geological Society of America, v. 63, p. 939-952.

Kerr, J. Wm.
1977: Cornwallis fold belt and the mechanism of basement uplift; Canadian Journal of Earth Sciences, v. 14, p. 1374-1401.

Kerr, J. Wm. and Christie, R.L.
1965: Tectonic history of the Boothia uplift and Cornwallis fold belt; American Association of Petroleum Geology, Bulletin, v. 49, p. 905-926.

Kerr, J. Wm. and deVries, C.D.S.
1977: Structural geology of Somerset Island and Boothia Peninsula, District of Franklin; *in* Report of Activities, Geological Survey of Canada, Paper 77-1A, p. 107-111.

Kerr, J. Wm. and Ruffman, A.
1979: The Crozier Strait fault zone, Arctic Archipelago, Northwest Territories, Canada; Canadian Petroleum Geology, Bulletin, v. 27, no. 1, p. 39-52.

Lowdon, J.A. and Blake, W., Jr.
1978: Geological Survey of Canada radiocarbon dates XVIII; Geological Survey of Canada, Paper 78-7.
1979: Geological Survey of Canada radiocarbon dates XIX; Geological Survey of Canada, Paper 79-7.

Lowdon, J.A., Fyles, J.G., and Blake, W., Jr.
1967: Geological Survey of Canada radiocarbon dates VI; Geological Survey of Canada, Paper 67-2, Part B, 42 p.

Lowdon, J.A., Robertson, I.M., and Blake, W., Jr.
1977: Geological Survey of Canada radiocarbon dates XVII; Geological Survey of Canada, Paper 77-7.

Mackay, J.R.
1953: Fissures and mudcircles on Cornwallis Island, Northwest Territories; Canadian Geographer, v. 3, p. 31-37.

McCann, S.B. and Cogley, J.G.
1973: The geomorphic significance of fluvial activity at high latitudes; *in* Research in Polar and Alpine Geomorphology, ed. B.P. Fahey and R.D. Thompson; 3rd Guelph Symposium on Geomorphology (Guelph, Ontario), p. 118-135.

Prest, V.K., Grant, D.R., and Rampton, V.N.
1968: Glacial map of Canada; Geological Survey of Canada, Map 1253A, scale 1:5 000 000.

Tarnocai, C.
1976: Soils of Bathurst, Cornwallis and adjacent islands, District of Franklin; *in* Report of Activities, Part B, Geological Survey of Canada, Paper 76-1B, p. 137-141.

Thorsteinsson, R.
1957: Summary of geology of Cornwallis and Little Cornwallis islands; Geological Survey of Canada, Bulletin 38, p. 3-11.
1958: Cornwallis and Little Cornwallis islands, District of Franklin, N.W.T.; Geological Survey of Canada, Memoir 294, 134 p.
1972: Geological maps of parts of the Canadian Arctic Archipelago; Resolute (58 F), Baillie-Hamilton (58 G), Lowther Island (68 E), and McDougall Sound (68 H); Geological Survey of Canada, Open File 139, scale 1:125 000.

Thorsteinsson, R. and Kerr, J.W.
1968: Cornwallis and adjacent smaller islands, Canadian Arctic Archipelago; Geological Survey of Canada, Paper 67-64, 16 p.

Walker, R.E. and Lake, R.A.
1975: Runoff in the Canadian Arctic Archipelago; *in* Climate of the Arctic, ed. G. Weller and S.A. Bowling; 24th Alaska Science Conference, Geophysical Institute of University of Alaska, Fairbanks, Alaska, p. 374-378.

Washburn, A.L.
1980: Geocryology; John Wiley & Sons, New York, 406 p.
1983: Palsas and continuous permafrost; *in* Proceedings, 4th International Conference on Permafrost (Fairbanks, Alaska); National Academy Press, Washington, D.C., p. 1372-1377.
1985: Radiocarbon dates from Cornwallis Island area, Arctic Canada—an interim report; Canadian Journal of Earth Sciences, v. 22, no. 4, p. 630-637.

Wilkinson, T.J. and Bunting, B.T.
1975: Overland transport of sediment by rill water in a periglacial environment in the Canadian High Arctic; Geografiska Annaler, no. 57A, p. 105-116.

APPENDIX 1

Sedimentological data, samples from the Cornwallis Island area, Northwest Territories

Sample No.* (cf. Fig. 14)	Map unit	Thaw depth cm	pH	Calcite-dolomite C/D	Calcite-dolomite total C + D %	Grain size Sand %	Silt %	Clay %	Atterberg limits Liquid limit %	Plastic limit %	Plasticity index %	H_2O content %
Cornwallis Island												
C1	1a	48	8.2	0.19	35.1	42.6	42.7	14.7	19	15	4	10
C2	4a1	-	8.2	1.1	8.6	76.1	16.5	7.4	-	-	-	5
C3	1a	40	8.2	1.1	56.3	37.8	40.3	21.9	19	15	4	10
C4	2b	47	7.6	0.1	0.8	58.6	21.9	19.5	27	22	5	17
C5	1a	38	7.8	5.8	61.4	19.8	52.4	27.8	23	19	4	20
Little Cornwallis Island												
C6	2a2	34	7.6	-	-	72.0	18.1	9.9	59	52	7	20
C7	2a2	31	7.8	-	-	74.1	15.6	10.3	-	-	-	13
C8	R2	-	7.6	0.5	11.2	42.9	36.9	20.0	-	-	-	18
C9	*R2	39	8.2	9.1	34.4	35.2	47.4	17.4	33	17	3	-
C10	R3	-	8.0	1.0	12.6	42.6	52.1	5.3	-	-	-	11
C11	R3	52	8.2	0.2	55.6	43.3	40.3	16.5	20	17	3	-
C12	1a	43	8.2	1.6	49.6	47.8	33.1	19.1	26	20	6	-
C13	R2	54	-	-	-	-	-	-	-	-	-	Excess
C14	2a2	30	7.6	-	-	68.4	22.4	9.2	-	-	-	17
C15	2a2	42	8.0	0.6	24.4	88.9	7.6	3.5	-	-	-	12
C16	2b	26	8.2	2.1	15.9	59.3	29.0	11.7	-	-	-	
C17	*R3	51	8.0	0.3	46.8	59.6	27.9	12.5	16	15	1	12
C18	2b	45	8.2	0.2	53.0	62.2	28.0	9.8	-	-	-	-
C19	2a1	42	8.2	0.3	52.1	32.3	30.1	37.6	28	18	10	14
C20	*R3	45	7.6	0.4	16.5	45.4	26.8	27.8	26	16	10	16
Cornwallis Island												
C21	2a1	51	8.0	1.0	17.3	41.1	50.4	8.5	-	-	-	13
C22	1a	39	7.6	0.0	26.2	17.5	32.2	50.3	41	23	18	32
C23	2b	51	7.8	0.0	13.7	33.2	28.9	37.9	35	21	14	26
C24	*R3	-	8.2	0.0	84.9	95.2	3.6	1.2	-	-	-	7
C25	2a2	40	7.4	0.0	18.6	28.2	60.3	11.5	31	25	6	13
C26	2b	40	7.6	0.0	18.6	28.2	60.3	11.5	38	22	16	26
C27	2a2	36	8.2	-	-	82.9	10.6	6.5	-	-	-	-
C28	*R2	40	7.6	3.7	52.8	39.2	29.0	31.8	34	22	12	20
C29	*R2	34	8.0	-	-	76.0	15.9	8.1	-	-	-	-
C30	1a	49	8.0	0.0	88.6	40.5	52.9	6.6	17	16	1	-
C31	1a	50	8.0	0.1	66.4	58.6	11.3	16	14	2	6	
C32	3b	45	8.2	0.1	?	13.0	66.2	20.8	25	20	5	15
C33	R1	52	7.8	3.3	52.0	29.4	55.5	15.1	21	15	6	11
C34	R3	34	8.2	0.0	14.7	41.6	44.5	13.9	-	-	-	10
C35	4a	49	7.8	1.4	90.4	22.0	46.6	31.4	24	13	11	-
C36	5a	37	7.8	4.9	66.3	23.5	48.9	27.6	-	-	-	9
C37	4b	30+	7.4	33.4	58.5	24.8	39.1	36.1	24	16	8	9
C38	4b	54	8.2	3.6	49.4	31.9	39.0	29.1	22	14	8	14
C39	R3	43	7.4	0.2	43.5	42.2	30.2	18.6	19	15	4	10
C40	1a	38	7.8	0.5	38.4	30.4	36.2	33.5	-	-	-	19
C41	*R3	55	8.0	0.8	54.5	41.1	40.0	18.8	18	14	4	11
C42	2a1	50	8.2	0.1	86.0	89.5	8.4	2.1	-	-	-	3
C43	*R3	47	7.8	1.0	83.8	20.0	59.5	20.5	31	25	6	23
C44	2a2	46+	8.2	1.0	64.2	64.5	24.5	11.5	-	-	-	5
C45	*R2	-	8.2	1.7	43.0	89.0	7.5	3.5	-	-	-	6
C46	*R2	41	7.6	0.3	65.5	34.4	45.4	20.2	26	21	5	10
C47	*R2	46+	7.6	2.2	48.0	38.4	36.8	24.8	-	-	-	10
C48	R3	20+	8.2	4.6	75.4	16.5	50.5	33.0	-	-	-	10
C49	2a1	48	8.2	0.3	65.4	53.4	33.4	13.2	18	16	2	10
C50	R3	42	8.2	0.0	0.1	26.0	63.6	10.4	17	15	2	7
C51	R3	60	6.8	0.1	88.4	32.4	46.0	21.6	-	-	-	10
C52	*R3	-	8.0	0.1	46.7	29.0	45.6	25.4	68	58	9	16
C53	1a	-	7.8	0.4	59.6	47.7	33.6	18.7	22	17	5	11
C54	2a1	-	8.2	1.8	55.6	68.6	21.7	9.7	-	-	-	15
C55	2a1	-	-	-	-	94.1	3.5	2.4	-	-	-	4
C56	1a	-	8.2	1.6	53.3	46.4	33.8	19.8	-	-	-	7
C57	*R3	-	8.2	0.2	43.0	51.5	35.7	12.8	-	-	-	8
C58	*R3	46	7.6	0.2	43.0	42.7	44.3	13.0	15	14	1	6
C59	*R3	65+	7.6	0.1	93.0	32.9	41.9	25.2	20	13	7	11
C60	5a	-	7.6	0.0	80.2	93.2	5.3	1.5	-	-	-	10
C61	*R3	33+	7.4	0.0	88.2	75.3	18.2	6.5	-	-	-	6

*Samples collected by D.M. Barnett and L.A. Dredge, August 10-24, 1975

Sample No.* (cf. Fig. 14)	Map unit	Thaw depth cm	pH	Calcite-dolomite C/D	Calcite-dolomite total C + D %	Grain size Sand %	Grain size Silt %	Grain size Clay %	Atterberg limits Liquid limit %	Atterberg limits Plastic limit %	Atterberg limits Plasticity index %	H_2O content %
Cornwallis Island cont.												
C63	*R3	55	7.6	0.1	76.6	52.0	39.4	8.6	15	14	1	10
C62	3b	55	7.6	0.2	63.9	59.6	33.4	7.0	-	-	-	11
C64	2a1	60	7.6	4.4	9.8	23.5	55.0	21.5	22	17	5	16
C65	*R3	25+	7.4	0.0	94.4	34.4	41.3	13.2	14	13	1	7
C66	R3	55	7.4	0.0	86.9	52.3	39.2	8.6	-	-	-	7
C67	3b	33	7.0	0.1	69.0	22.7	44.6	32.7	36	23	13	31
C68	5a	70	-	-	-	-	-	-	-	-	-	Excess
C69	R3	49	7.6	0.7	80.2	33.4	40.5	25.9	22	16	6	9
C70	R3	32	-	-	97.0	0.5	0.5	2.5	-	-	-	8
C71	5a	-	7.2	0.5	6.8	21.8	45.2	32.8	40	29	11	25
C72	5a	32	7.6	1.2	42.8	17.9	39.9	42.7	44	26	18	31
C73	5a	24	7.6	6.3	33.5	42.3	31.9	25.8	28	21	7	14
C74	5a	-	7.6	0.0	93.0	56.2	34.5	9.3	-	-	-	8
C75	*R3	-	7.6	0.4	41.7	42.0	40.9	17.1	24	19	5	12
C76	*R3	-	7.6	0.8	63.8	32.9	52.8	14.3	-	-	-	6
C77	*R3	-	7.2	0.2	62.1	11.7	41.8	46.4	33	21	12	20
C78	1a	-	7.0	0.8	56.7	56.1	24.2	19.8	-	-	-	7
C79	1a	-	7.6	0.8	63.8	32.9	52.8	14.3	-	-	-	11
C80	2b	50+	7.0	0.3	54.0	45.5	33.4	21.1	-	-	-	12
C81	R3	-	7.6	0.1	55.0	53.3	33.2	13.5	21	18	3	10
C82	R2	-	7.0	0.0	23.3	33.0	40.1	25.9	63	52	11	32
C83	R3	30+	8.0	-	-	86.5	11.9	1.6	-	-	-	4
C84	R3	50	7.8	92.0	92.0	80.8	17.8	1.4	-	-	-	7
C85	R2	50	7.6	0.0	26.7	29.4	54.3	13.3	-	-	-	14
C86	R2	53	7.4	1.0	48.1	33.2	53.4	13.4	-	-	-	16
C87	R2	45	7.2	0.3	41.9	11.7	61.8	26.5	-	-	-	25
C88	1a	51	7.2	0.7	60.2	19.8	47.7	32.5	-	-	-	11
C89	R3	55	7.4	0.3	56.4	35.0	43.9	21.1	-	-	-	9
C90	1a	52	-	-	-	-	-	-	-	-	-	Excess
C91	3b	-	8.2	0.9	67.8	89.6	8.1	2.3	-	-	-	4
C92	3b	-	7.2	0.3	53.8	43.1	44.1	12.7	-	-	-	22
C93	3b	-	8.2	0.6	55.0	58.7	27.1	14.3	-	-	-	11
C94	1a	52+	7.2	0.4	71.2	25.3	50.5	24.2	27	21	6	17
C95	R2	-	7.8	0.1	50.4?	14.5	57.3	28.2	-	-	-	19
C96	R2	4?	7.8	0.1	50.4	26.8	44.3	29.0	42	31	11	12
C97	*R2	58	7.8	1.1	9.1	69.0	17.2	13.8	-	-	-	12
C98	2b	52	8.0	0.2	29.2	32.8	40.7	26.6	29	19	10	19
C99	1a	53+	7.8	0.1	55.8	50.4	32.0	16.8	21	16	5	9
C100	4a2	-	7.6	0.0	9.4	23.4	60.5	16.1	19	17	2	7
C101	1a	49	-	0.0	87.2	34.5	56.5	9.0	16	13	3	8
C102	1a	37	-	2.2	35.0	35.9	48.8	15.3	-	-	-	8
C103	1b	55	-	0.2	22.1	41.2	36.9	21.9	-	-	-	16
C104	1b	56	-	0.1	14.8	45.6	36.4	17.9	20	15	5	13
C105	1b	-	-	0.1	16.1	40.6	35.8	23.6	22	14	8	15
C106	1a	40	-	0.2	94.4	24.8	60.7	14.6	-	-	-	9
C107	1a	59	-	0.1	72.6	36.3	49.0	14.7	-	-	-	10
C108	1a	57	-	0.0	93.0	56.9	33.6	9.5	-	-	-	14
C109	1a	57	-	0.5	77.4	29.1	45.6	25.3	-	-	-	11
C110	*R3	-	-	0.8	72.4	61.6	23.0	15.4	-	-	-	5
C111	*R3	53	-	0.0	90.0	33.5	61.1	5.4	-	-	-	15
C112	1a	-	-	1.6	64.1	31.6	51.0	17.4	-	-	-	9
C113	*R3	-	-	0.4	67.8	39.7	38.7	21.7	-	-	-	14
C114	*R3	-	-	0.0	69.2	30.8	42.5	26.8	25	17	8	9
C115	*R3	-	-	0.1	83.6	2.6	72.3	25.1	23	18	5	28
C116	*R3	-	-	0.1	96.4	72.5	22.0	5.5	-	-	-	3
C117	1a	-	-	0.1	58.0	40.1	44.1	15.8	-	-	-	3
C118	4b	48	-	1.3	67.4	17.6	52.7	29.7	21	15	6	17
C119	4b	62	-	1.8	59.6	43.3	36.8	19.9	18	13	5	10
C120	4b	-	-	0.2	11.3	40.9	47.4	11.7	16	15	1	9
C121	R3	60	-	0.0	83.2	37.6	43.2	19.2	17	14	3	11
C122	R3	-	-	1.7	83.0	24.6	42.3	33.1	-	-	-	11
C123	R3	30	-	-	-	96.7	0.6	2.7	-	-	-	8
C124	2b	-	-	0.3	15.3	17.2	68.6	14.2	33	29	4	23
C125	2a2	50	-	0.1	13.9	26.0	60.0	14.0	-	-	-	14
C126	R3	60	-	0.3	46.1	72.1	19.6	8.3	-	-	-	11
C127	4a2	72	-	0.1	77.2	42.7	44.3	13.0	-	-	-	6
C128	R3	-	-	-	-	54.7	32.2	13.1	-	-	-	9

Appendix 1 (cont'd.)

Sample No.* (cf. Fig. 14)	Map unit	Thaw depth cm	pH	Calcite-dolomite C/D	Calcite-dolomite total C + D %	Grain size Sand %	Grain size Silt %	Grain size Clay %	Atterberg limits Liquid limit %	Atterberg limits Plastic limit %	Atterberg limits Plasticity index %	H_2O content %
Cornwallis Island cont.												
C129	R3	-	-	2.2	52.3	3.6	58.0	38.4	-	-	-	15
C130	*R3	58	-	0.2	80.0	27.4	59.6	13.0	19	19	0	19
C131	*R3	58	-	0.5	73.9	64.8	24.2	11.0	-	-	-	6
C132	*R3	-	-	0.9	79.8	33.8	41.7	24.5	19	13	6	11
C133	*R3	-	-	0.9	69.7	51.4	35.0	13.6	-	-	-	8
C134	4b	54	-	1.8	71.0	-	-	-	35	18	17	13
C135	4b	54	-	17.5	81.6	10.4	36.9	52.7	37	17	20	19
C136	4b	42	-	1.3	63.2	21.7	40.0	38.4	26	16	10	13
C137	4b	47	-	103.5	83.6	29.4	30.6	40.0	-	-	-	8
C138	5a	32	-	0.3	38.6	8.9	67.9	23.2	34	26	8	27
C139	1a	56	-	6.4	57.6	44.9	39.4	15.4	18	15	3	8
C140	1a	25+	-	1.5	73.6	39.1	36.7	24.2	-	-	-	8
C141	1a	49	-	5.4	61.8	24.2	41.2	34.6	27	17	10	13
C142	3b	-	-	0.1	95.6	42.2	44.1	13.8	-	-	-	8
C143	4b	-	-	0.4	91.0	30.6	51.2	18.3	-	-	-	8
Lowther Island												
C144	2a1	50	-	0.7	9.5	45.2	26.8	28.0	-	-	-	20
C145	1b	70	-	0.5	15.8	37.8	32.2	30.0	23	12	11	13
C146	1b	47	-	1.0	9.6	37.7	31.8	30.5	23	12	11	13
C147	*R3	60	-	0.3	28.0	52.7	28.9	18.5	20	14	6	12
Griffith Island												
C148	2b	46+	-	-	-	44.1	35.4	20.5	-	-	-	42
C149	2b	46+	-	0.0	23.5	19.5	46.7	33.7	24	15	9	14
C150	2b	46+	-	0.3	67.5	40.3	39.7	19.9	18	14	5	9
C151	5a	42+	-	0.9	25.9	27.8	55.9	16.2	26	21	5	17
C152	R3	-	-	0.7	53.8	16.0	52.9	31.1	29	18	11	16
C153	5a	30+	-	2.0	2.0	36.5	5.3	8.2	-	-	-	10
C154	5a	30+	-	-	-	31.3	48.1	20.6	21	17	4	15
C155	2b	-	-	2.0	2.0	86.5	5.3	8.2	-	-	-	7
C156	2a1	-	-	3.2	3.2	58.1	25.6	16.3	-	-	-	16
C157	*R3	70	-	0.0	27.2	72.4	18.0	9.6	-	-	-	9
Cornwallis Island												
C158	1a	71	-	0.0	15.1	44.4	31.9	23.7	22	15	7	14
C159	3b	42	-	0.0	80.1	85.7	11.5	2.9	-	-	-	13
C160	3b	42	-	0.0	92.0	74.2	21.7	4.1	-	-	-	15
C161	3b	43	-	0.8	12.7	82.4	14.3	3.3	-	-	-	12
C162	*R3	70	-	0.0	83.2	66.6	30.6	2.8	-	-	-	19
C163	R3	55	-	0.2	11.4	62.3	33.7	4.0	-	-	-	8
C164	R3	36	-	0.0	90.4	27.4	65.4	7.2	-	-	-	17
C165	4b	46	-	0.2	58.2	38.4	48.3	15.3	18	15	3	9
C166	*R3	-	-	0.2	76.8	35.3	45.7	19.0	16	13	3	10
C167	1a	52	-	0.7	63.1	32.1	40.0	27.9	23	17	6	15
C168	3b	37	-	0.2	54.3	33.2	52.6	14.3	-	-	-	20
C169	2b	44	-	2.1	41.9	81.0	15.3	3.7	-	-	-	9
C170	2b	-	-	0.3	37.9	69.6	19.7	10.7	-	-	-	9
C171	2b	-	-	4.2	6.3	93.5	3.3	3.2	-	-	-	12
C172	3b	-	-	0.7	48.2	89.6	7.6	2.8	-	-	-	4
C173	3b	-	-	9.8	38.8	15.3	68.7	16.0	-	-	-	10
C174	R3	-	-	0.8	31.7	44.5	34.1	21.5	-	-	-	15
Baillie-Hamilton Island												
C175	1a	77	-	11.5	94.6	48.0	26.1	25.9	19	11	8	12
C176	1a	52	-	1.7	36.7	38.7	37.3	24.4	-	-	-	15
C177	1a	40	-	1.4	9.6	51.1	23.5	25.4	19	12	7	13
C178	4a1	50	-	1.7	106.0	49.7	25.8	24.5	23	15	8	14
C179	4a2	40+	-	2.3	27.0	47.6	36.1	16.3	-	-	-	14
C180	2a1	49	-	3.7	23.6	56.3	30.2	13.5	-	-	-	16
C181	1a	45	-	6.4	14.0	50.1	27.6	22.4	19	13	6	15
C182	R2	55	-	0.1	15.0	51.9	27.6	20.5	-	-	-	13
C183	2a1	30+	-	0.6	34.0	52.4	31.4	16.2	-	-	-	12

*Samples collected by D.M. Barnett and L.A. Dredge, August 10-24, 1975

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